

ONLINE TABLE 2: GENETIC DEFECTS IN HUMAN MALE REPRODUCTIVE DISORDERS

Abbreviations: HHG: hypogonadotropic hypogonadism, CAH : congenital adrenal hyperplasia

*case report

** case report

ABB	GENE NAME	TYPE OF MUT	FUNCTION	PHENOTYPE	REF
17HSDB3	17-beta hydroxysteroid dehydrogenase 3	Missense	Steroid metabolism	XY pseudohermaphroditism	¹
ACE	Angiotensin-converting enzyme	ACE-II polymorphism	Conversion of angiotensinogen to angiotensin	Posterior urethral valve	²
ACE and TNF-beta	Angiotensin converting enzyme and tumor necrosis factor-beta	polymorphisms	ACE: Conversion of angiotensinogen to angiotensin, TNF-beta: cytokine	Various sperm abnormalities	³
ACT	activator of cAMP-responsive element modulator in the testis	single-nucleotide polymorphisms	Phosphorylates CREM transcription factor (activation)	Azoospermia , oligozoospermia	⁴
AFL	TFIIB-alpha/beta-like factor gene	2p21	human spermatogenesis related gene,	abnormal expression of AFL might be the partial cause for human infertility, may function in spermatogenesis, especially in spermiogenesis.	⁵
AHRR	aryl hydrocarbon receptor repressor	Arg554Lys polymorphism	Repressor for aryl hydrocarbon receptor	Micropenis	⁶
AHRR	aryl hydrocarbon receptor repressor	Pro185Ala	Repressor for aryl hydrocarbon receptor	Micropenis	⁷
AHRR	aryl hydrocarbon receptor repressor	Ala185Ala	Repressor for aryl hydrocarbon receptor	Azoospermia or oligozoospermia	⁸ ⁹
AKAP3, AKAP4	A-kinase anchor protein 3 and 4	Deletion	Adaptor protein, Kinase anchor protein	Asthenozoospermia	¹⁰
ALDH1A2	aldehyde dehydrogenase 1 family, member A2	Polymorphisms (various)	Retinoic acid metabolism	Spina bifida (erectile dysfunction)	¹¹
ALG12	asparagine-linked glycosylation 12 homolog	301 G > A (G101R) mutation and 437 G > A (R146Q) mutation	Production of lipid-linked oligosaccharides	Micropenis	¹²
AMH	Anti-Mullerian Hormone	Substitution/Deletion	AMHR ligand glycoprotein hormone	Persistent Mullerian duct syndrome	¹³
AMHR	Anti-Mullerian Hormone Receptor	Substitution/Deletion	Transmembrane Receptor (Type II)	Persistent Mullerian duct syndrome	¹⁴

A-myb	v-myb myeloblastosis viral oncogene homolog (avian)-like 1	Deletion	Regulator nuclear transcription proteins	Degeneration of primary spermatocyte, arrest at pachytene	¹⁵
ApoA-I	apolipoprotein A-I	Deletion	Lipid metabolism	Amyloidosis causing infertility, macroorchidism, and hypogonadism	¹⁶
ApoA-I	Apolipoprotein A-I	Missense	Lipid metabolism	Testicular amyloidosis	¹⁷
ApoB	apolipoprotein B	insertion/deletion (I/D) polymorphism	Lipid metabolism	Azoospermia and oligoasthenoteratozoospermia	¹⁸
AR	Androgen receptor	Increased GGN repeats	Steroid receptor	Hypospadias, Cryptorchidism	¹⁹
AR	Androgen receptor	Mutation	Steroid receptor	TGCT	²⁰
AR	Androgen receptor	Substitution/Insertion	Steroid receptor	androgen insensitivity syndrome (AIS), infertility, cryptorchidism, gynaecomastia, low virilization or hypospadias	²¹
AR	Androgen receptor	Polymorphism	Steroid Receptor	Male Infertility	²²
AR	Androgen receptor	CAG expansion	Steroid receptor	Kennedy Disease, male infertility and defective spermatogenesis, CAH	^{23 24} ²⁵
AR	Androgen Receptor	Missense mutations	Androgen hormone receptor	Impaired spermatogenesis	²¹
ART3	ADP-ribosyltransferase 3 gene	SNPs	Post-translational modification of proteins	Azoospermia	²⁶
ARX	Aristaless related homeobox	Mutation	Homeobox gene	X-linked lissencephaly with ambiguous genitalia, cryptorchidism	²⁷
ATF3	Activating transcription factor 3	3 common SNPs	Estrogen-responsive gene	Hypospadias	²⁸
ATF3	Activating transcription factor 3	Up-regulation	Estrogen responsive gene	Hypospadias	²⁹
ATM	Ataxia telangiectasia mutated	mutations	Ataxia telangiectasia	Abnormal meiosis, germ cell apoptosis	³⁰
ATPase 6	Adenosine triphosphatase 6	Mutation T8821C	ATP metabolism	Severe oligospermia	³¹
AURKC	Aurora kinase C	Deletion/Frameshift single nucleotide deletion	Kinase	large-headed multiflagellar polyploid spermatozoa	³²
AZFa (USP9Y/ DBY)	Azoospermia factor a	Deletion	spermatogenesis	Sertoli-cell only syndrome, azoospermic	³³
AZFb (RBMY)	Azoospermia factor b	Deletion	spermatogenesis	severe oligozoospermia to azoospermia	³⁴

AZFB	Azoospermia factor b	Complete Deletion	spermatogenesis	Non-Obstructive Azoospermia	³⁵
AZFc (DAZ)	Azoospermia factor c	Deletion gr/gr deletions, Partial deletions of the AZFc region of the Y chromosome	spermatogenesis	severe oligozoospermia to azoospermia	³⁶
BHMT2	Betaine-homocysteine methyltransferase	742G-->A (R239Q)	Folate metabolism	Spina bifida (erectile dysfunction)	³⁷
BIRC7/ LIVIN	Baculoviral IAP Repeat-Containing 7	Expression	Inhibitor of apoptosis	Testicular germ cell tumors	³⁸
BOULE	BOULE-like	Splice variants	mediator of meiotic transition	Spermatogenic failure	³⁹
BPY2	Basic protein on Y chromosome, 2	SNP	spermatogenesis	Sertoli-cell only	⁴⁰
BRCA1	Breast cancer 1	Polymorphisms (various)	Tumor suppressor	Spina bifida (erectile dysfunction)	⁴¹
BRCA2	Breast cancer 2	N372H polymorphism	Tumor suppressor	azoospermia or severe oligozoospermia	⁴²
CATSPE R2	Cation channel, sperm associated 2	Deletion	voltage-gate cation channel	congenital dyserythropoietic anemia type I. Asthenoteratozoospermia	⁴³
CATSPE R2	Cation Channel, Sperm Associated 2	Genomic Deletion at 15q15.3	voltage-gate cation channel	Deafness-infertility syndrome	⁴⁴
CCL2	chemokine (C-C motif) ligand 2	A(-2518)G promoter polymorphism	Chemotaxis	Spina bifida (erectile dysfunction)	⁴⁵
CDY1	Chromodomain protein, Y-linked, 1	Deletion	chromadomain protein 1	Sertoli cell only, Hypospermatogenesis, does not worsen DAZ deletion	⁴⁶
CDY1	chromodomain protein, Y-linked, 1	single nucleotide variants (SNV)	protein containing a chromodomain and a histone acetyltransferase catalytic domain	azoospermia, cryptozoospermia or severe oligozoospermia	⁴⁷
CFL1	Human non-muscle cofilin	rs652021, rs665306, rs667555, rs4621 and rs11227332 SNPs	actin-depolymerizing factor	Spina bifida (erectile dysfunction)	⁴⁸
CFTR	Cystic fibrosis transmembrane regulator	Missense/Substitution	membrane transport channel	bilateral absence of vas deferens, infertile	⁴⁹
CFTR	Cystic fibrosis transmembrane regulator	Mutation polymorphism	Ion Channel	Congenital Bilateral Absence of the Vas Deferens	⁵⁰
CFTR	Cystic fibrosis transmembrane regulator	Polymorphism	Ion Channel	Congenital Bilateral Absence of the Vas Deferens	⁵¹
CFTR	Cystic fibrosis transmembrane	Polymorphisms	Cystic fibrosis transmembrane	Obstructive azoospermia, secretory	⁵²

	regulator gene		conductance regulator	azoospermia and severe oligozoospermia, male infertility	
CHD7	Chromodomain helicase DNA binding protein 7	Truncating/Missense	DNA-binding protein	CHARGE syndrome, delayed puberty, HHG, genital hypoplasia	⁵³
Cited2	Cbp/p300-interacting transactivator	SNP (various)	cAMP-responsive element-binding protein	Spina bifida (erectile dysfunction)	⁵⁴
c-KIT	v-kit Hardy-Zuckerman 4 feline sarcoma viral oncogene homolog	Activating/Missense	tyrosine-kinase receptor	Germ cell tumors	⁵⁵
c-KIT	v-kit Hardy-Zuckerman 4 feline sarcoma viral oncogene homolog	Activating mutation at codon 816	Tyrosine kinase receptor	Testicular germ cell tumors	⁵⁶
CKMT1B	Creatine Kinase, Mitochondrial 1B	Genomic Deletion at 15q15.3	Kinase	Deafness-infertility syndrome	⁴⁴
CLDN16	Claudin 16	?	Cell adhesion protein/tight junctions	Severe oligospermia 2 Brothers: case report	⁵⁷
contactin associated protein-like 3	CNTNAP3	Disruption by 46,XY,t(8;9)(p11.2;q13)	Cell recognition within nervous system	Exstrophy/epispadias	^{58*}
CREM	cAMP responsive element modulator	Insertion/Mutation/ SNP	transcripton factor	Round spermatid maturation arrest	⁵⁹
CREM	cAMP responsive element modulator	Deletion	Activator isoform	Round spermatid maturation arrest	⁶⁰ ,
CTNNB-1	Beta-catenin	Overexpression	regulator of cellular differentiation	Gonadoblastoma	⁶¹
Cx43	Connexin 43	deletion	proteins that form gap junction channels	Degenerated seminiferous tubules and impaired spermatogenesis	⁶²
CYP11A1	Cytochrome P450, family 11, subfamily A, polypeptide 1	Multiple mutations: missense; frameshift; splice site mutations;	Converts cholesterol to pregnenolone	Gonadal dysgenesis, XY-sex reversal, diminished steroidogenesis	⁶³
CYP11B1	Cytochrome P450, family 11, subfamily B, polypeptide 1	Multiple mutations: missense; nonsense; frameshift; splice site mutations;	Steroid biosynthesis	CAH, 11beta-hydroxylase deficiency	^{64*} ^{65*} ^{66*} ^{67*} ^{68*} ^{69*}
CYP11B2/CYP11B1 chimeric gene	Cytochrome P450, family 11, subfamily B, polypeptide 2	Chimeric gene controlled by CYP11B2 promotor that does not function in the zona	Steroid biosynthesis	CAH 11beta-hydroxylase deficiency	^{65*}

		fasciculata/reticularis			
CYP17	Cytochrome P450, family 17, subfamily A, polypeptide 1	Multiple mutations: duplication, frameshift, missense	enzyme	female external genitalia, absence of sex steroids, CAH 17 alpha-hydroxylase/ 17,20-lyase deficiency	⁷⁰ ^{71*} ^{72*}
CYP19	P450, family 19, subfamily A, polypeptide 1	Substitution	enzyme	bilateral cryptorchidism (germ cell depletion), high FSH	⁷³
CYP21 5' non-coding region	Steroid 21-hydroxylase	Mutation T295C A294C A283G	5' untranslated region of CYP21	CAH 21-hydroxylase deficiency	⁷⁴
CYP21	Cytochrome P450, family 21, subfamily A, polypeptide 2	Multiple mutations: point, deletion, splice site mutation, partial gene conversion, nonsense, missense, insertion	Steroid biosynthesis	CAH, testicular tumor, 21-hydroxylase deficiency	^{75,76} ^{77,78} ^{79 80} ^{81 82} ^{83 84} ^{85*8} ⁶
CYP21A2	Cytochrome P450, family 21, subfamily A, polypeptide 2	Multiple mutations: duplication, point, deletion, splice site mutation, partial gene conversion, nonsense, missense, insertion, premature stop codon	Steroid biosynthesis	CAH 21-hydroxylase deficiency	^{87,88} ^{* 76} ⁸⁹ ^{77 90} ^{91 92} ^{93*9} ^{4 95} ^{79 77} ^{96 97} ⁹¹
CYP21A2 Promoter	Promoter of cytochrome P450, family 21, subfamily A, polypeptide 2	15 heterozygous variants	member of the cytochrome P450 superfamily of enzymes	CAH 21-hydroxylase deficiency	^{98*} ⁹⁹
DAZ	Deleted in azoospermia 1	Deletion	Deleted in Azoospermia	Sertoli cell only, severe oligospermia	¹⁰⁰
DAZ	Deleted in azoospermia 1	single nucleotide variants (SNV)	RNA-binding protein important for spermatogenesis	azoospermia, cryptozoospermia or severe oligozoospermia	⁴⁷
DAZL	deleted in azoospermia-like	polymorphisms, GR/GR deletion	Y-borne testis-specific gene families of BPY2, CDY1, DAZ,	Abnormal spermatogenesis Spermatogonial arrest, loss of germ cells and complete absence of gamete production	¹⁰¹
DAZL	deleted-in-azoospermia-like	polymorphism Thr54Ala		spermatogenic failure in the Taiwanese population	
DBY	DEAD box polypeptide 3, Y-linked	Deletion	Dead boxy on the Y	Sertoli cell only	¹⁰²

DDX25 / GRTH	Gonadotropin-Regulated Testicular RNA Helicase	SNP/ Missense mutation	alteration of RNA secondary structure, such as translation initiation, nuclear and mitochondrial splicing, and ribosome and spliceosome assembly loss of GRTH phosphorylation	Association of GRTH polymorphism with azoospermia/oligospermia Infertility in Japanese men	^{103,104}
DDX4	DEAD (Asp-Glu-Ala-Asp) box polypeptide 4	Decreased expression	putative RNA helicase	oligozoospermic men	¹⁰⁵
DIABLO	diablo homolog (<i>Drosophila</i>)	Down-regulation	Pro-apoptosis	TGCT	¹⁰⁶
DNAI1 DNAH5 DNAH11	Dynein	Mutations	Motor protein subunits	Asthenozoospermia, reduced forward motility	¹⁰⁷
DPPA2/ PESCRG 1/ ECSA	Developmental Pluripotency Associated 2		pluripotent stem cell genes	reprogramming in development, late and abnormal gametogenesis,	¹⁰⁸
DRFFY/ USP9X/ DFFRX/ FAF/ FAM	Ubiquitin Specific Peptidase 9	Deletion	Homologous to <i>Drosophila</i> fat facets (faf) gene	Azoospermia, hypospermatogenesis(retained DBY)	¹⁰⁹
eEF1A	Eukaryotic Translation Elongation Factor 1 Alpha 1	Increased expression	Eukaryotic translation elongation factor	testicular germ cell tumors	¹¹⁰
EFNB2	Ephrin-B2	deletion	Cell-cell recognition	Hypospadias & incomplete cloacal septation	¹¹¹
EGFR	Epidermal Growth Factor Receptor	Chromosomal polysomy/amplification	epidermal growth factor receptor	metastatic embryonal carcinoma	¹¹²
EIF5A2/ eIF-5A2 protein	Eukaryotic Translation Initiation Factor 5A2				¹¹³
eNOS	Nitric-Oxide Synthase, Endothelial	894G>T SNP	Nitric oxide metabolism	Spina bifida	^{114 109}
ER alpha promoter of	promoter of the Estrogen Receptor alpha	(TA)n repeat allelic variants	Nuclear receptor	association between higher TA repeat number and lower sperm production	¹¹⁵
ERCC1	Excision Repair Cross-Complementing 1	ERCC1 polymorphisms 3 UTR (C8092A)	DNA damage repair and genomic instability in germ cells excision repair cross complementation groups 1 & 2	Polymorphism associated with an increased risk of idiopathic azoospermia	¹¹⁶

ERCC1	Excision repair cross complementation group 1	ERCC1 polymorphisms 3 UTR (C8092A)	DNA damage repair and genomic instability in germ cells	Polymorphism associated with an increased risk of idiopathic azoospermia	¹¹⁶
ERCC2/XPD	Excision repair cross complementation group 2	Lys751Gln	DNA damage repair and genomic instability in germ cells	Polymorphism associated with an increased risk of idiopathic azoospermia	¹¹⁷
ESR1	Estrogen Receptor 1	Homozygous mutation C157T	Estrogen receptor	Fertility unknown	¹¹⁸
ESR1	Estrogen Receptor 1	'AGATA' haplotype within a 50 kb linkage disequilibrium (LD) block	Estrogen receptor alpha	Hypospadias	¹¹⁹
ESR1	Estrogen Receptor 1	C-A haplotype	Estrogen receptor alpha	Hypospadias	¹²⁰
ESR1	Estrogen Receptor 1	SNP12 (rs6932902)	estrogen receptor alpha	Cryptorchidism (Not associated with occurrence of cryptorchidism but with severity of cryptorchidism)	¹²¹
ESR1	Estrogen Receptor 1	g.938T>C		excess of homozygous infertile men for the ESR1 g.938T>C marker	¹²²
ESR2	Estrogen Receptor 2	silent polymorphism RsaI (G1082A)		frequency of the heterozygous RsaI. AG-genotype higher in infertile men	¹²³
ESR2	Estrogen Receptor 2	(CA)n polymorphism in intron 6, SNP: rs2987983, Promoter single nucleotide polymorphism: rs10483774	Estrogen receptor	Hypospadias	¹²⁴
ERS1	Estrogen Receptor 1	AGATA haplotype	Receptor for estrogen	Micropenis	¹¹⁹
FASLG	Fas Ligand	SNP in codon 844	Interacts with Fas to trigger apoptosis in some cell types	genetic predisposing factor of idiopathic azoospermia or severe oligozoospermia among southern Chinese Han males , azospermia, oligospermia	¹²⁵
FGFR1	Fibroblast Growth Factor Receptor 1	Missense/Nonsense	receptor tyrosine kinase	Kallmann's syndrome, cryptorchidism, microphallus, delayed or absent puberty	¹²⁶
FGFR1	Fibroblast Growth Factor Receptor 1	heterozygous nonsense mutation, Arg622X,	Fibroblast growth factor receptor 1	Autosomal dominant, normosmic hypogonadotropic hypogonadism	¹²⁷
FGFR1	Fibroblast Growth	Loss of function	Fibroblast growth	Kallmann's Syndrome,	¹²⁸

	Factor Receptor 1	mutation	factor receptor 1	cryptorchidism	
FGFR2	Fibroblast Growth Factor Receptor 2	Polymorphism c.2454C>T	Fibroblast growth factor receptor 2	Hypospadias	¹²⁹
FKBP6	FK506 Binding Protein 6		FK506-binding domain and tetratricopeptide protein-protein interaction domains	A of c.216C>A seems to be a protective factor for the development of male infertility	¹³⁰
FKBP6	FK506 Binding Protein 6	Polymorphism 245C --> G (Y60X)	FK506-binding protein 6	Azoospermia, meiotic arrest	¹³¹
FOXL2	Forkhead Box L2	aberrant intratesticular expression	Ovarian somatic cell differentiation and further follicle maintenance	Testicular cancer - JGCTT (juvenile granulosa cell tumor of the testis)	^{132*}
FSHR	Follicle Stimulating Hormone Receptor	Heterozygous Activating Mutations A1700G, A567G	Follicle stimulating hormone receptor	Active spermatogenesis in absence of gonadotropins	¹³³
FSHR	Follicle Stimulating Hormone Receptor	Polymorphism	Follicle stimulating hormone receptor	Abnormal spermatogenesis	¹⁰¹
FSH \square /BRD2	Bromodomain Containing 2	Deletion/Frameshift	FHSR ligand glycoprotein hormone	azoospermia, small testes, absent or present puberty	¹³⁴
G alpha 12/GNA12	Guanine Nucleotide Binding Protein (G protein) Alpha 12	Defective expression	subunit of guanine nucleotide regulatory proteins	spermatozoa with low motility	¹³⁵
G alpha s/HBA1	Hemoglobin, Alpha	Mutation (A366S)	G (guanine nucleotide-binding)-protein subunit	Sexual Precocity/testotoxicosis	¹³⁶
GHR	Growth Hormone Receptor	S226I in WSXWS-like motif of GHR	Receptor for growth hormone	Micropenis	^{137*}
GNRHR	Gonadotropin-Releasing Hormone Receptor	Missense	g-protein coupled receptor	complete to partial HHG	¹³⁸
GNRHR	Gonadotropin-Releasing Hormone Receptor	Ala129Asp/Arg262Gln	Endocrine regulation	hypogonadotropic hypogonadism	^{139*}
GNRHR	Gonadotropin-Releasing Hormone Receptor	R262Q mutation	GnRH receptor	isolated hypogonadotropic hypogonadism (IHH), oligospermia	^{140*}
GP130	Leucine-Rich PPR-Motif containing	Decreased expression	glycoprotein subunit 130	asthenozoospermic	¹⁴¹
GPR54	G protein-Coupled Receptor 54	Missense/Deletion/	g-protein coupled receptor	idiopathic HHG, small testes, sparse pubic hair, low levels of gonadotropins and sex steroids	¹⁴²
GRTH	Gonadotropin-Regulated Testicular RNA Helicase	SNP/Missense	testis-specific RNA helicase that is essential for completion of spermatogenesis RNA helicase	SNP IVS6+55G-->T and c.852C-->T of GRTH gene may be associated with male infertility with azoospermia or severe oligozoospermia	¹⁰³

GSP/ GSM1	Geniospasm 1	Activating mutation (R201C)	alpha-subunit of the G alpha i2 protein	Testicular Leydig Cell Tumors	¹⁴³
GSTM1	Glutathione S-Transferase M1	Deletion (null)	Glutathione transferase	Increased DNA adduct levels in sperm	¹⁴⁴
GSTM1	Glutathione S-Transferase M1	Polymorphism	Glutathione-S-transferase	DNA damage in sperm	¹⁴⁵
GSTM1	Glutathione S-Transferase M1	Polymorphism	GSTM1 is involved in detoxification of carcinogens	GSTM1 in association with mtDNA 4977 deletion is significantly associated with infertility (oligoasthenoteratozoo spermia)	¹⁴⁶
GSTT1	Glutathione S-Transferase Theta 1	Null mutation		significant association between the null alleles of GSTT1 and idiopathic azoospermia	¹⁴⁷
GSTT1	Glutathione S-Transferase Theta 1	Null mutation	catalyze the conjugation of reduced glutathione	oligospermia	¹⁴⁷
H19	Imprinted Maternally Expressed Transcript	Undermethylation in sperm	Imprinted genets	Oligospermia	¹⁴⁸
H2AFX	H2A Histone Family	variants	DNA repair to maintain the genomic integrity and ensure the proper meiotic process	silenced during human meiosis	¹⁴⁹
HBA	Alpha-globin	Inactivation/deletion (alpha-thalassemia)	Oxygen delivery by red blood cells	Spina bifida (erectile dysfunction)	¹⁵⁰
HBA	Alpha-globin	Inactivation/deletion (alpha-thalassemia)	Oxygen delivery by red blood cells	Micropenis	^{151*}
HBB	Beta-globin	Inactivation/deletion (beta-thalassemia)	Oxygen delivery by red blood cells	Spina bifida (erectile dysfunction)	¹⁵⁰
HILS1, TNP1, and TNP2	Histone Linker H1 Domain, Transition Protein 1&2	Decreased transcription	Spermatid-specific linker histone H1-like protein (HILS1), transition proteins 1 and 2	asthenozoospermic men	¹⁵²
HMGA1	High Mobility Group AT-Hook 1	Overexpression	Architectural factors	Testicular seminomas and embryonal carcinomas	¹⁵³
HMGA2	High Mobility Group AT-Hook 2	Overexpression	Architectural factors	Testicular embryonal carcinomas and yolk sac carcinomas	¹⁵³
HNF1B	Hepatocyte Nuclear Factor-1 Beta	Whole gene deletion	Transcription factor	Prune belly syndrome	^{154*}
HNF1B	Hepatocyte Nuclear Factor 1 Beta	Mutation	Renal cysts and diabetes syndrome	Atresia of the vas deferens	¹⁵⁵
HOXA13	Homeobox A13	TGG to TGA nonsense	Homeobox transcription factor	Hypospadias, as well as other defects of the uterus, bladder, ureter and distal limb	¹⁵⁶

HOXA13	Homeobox A13	PolyA expansion	Homeobox transcription factor	Hypospadias	¹⁵⁷
HOXA13	Homeobox A13	Missense/Nonsense	Homeobox transcription factor	Hand-foot-genital syndrome, hypospadias	¹⁵⁸
HOXD13	Homeobox D13	Polyalanine duplication band of nine additional alanine residues	Homeobox transcription factor	Hypospadias, hypoplastic synpolydactyly	¹⁵⁹
HOXD13	Homeobox D13	Missense mutation: 180A>G (A60A)	Homeobox transcription factor	Cryptorchidism	¹⁶⁰
HSD3B2	Hydroxy-Delta-5-Steroid Dehydrogenase	Splicing mutation: 1, In-frame deletion: 1, Nonsense mutations: 3, Frameshift mutations: 4, Missense mutations: 22 (Steroid biosynthesis	CAH 3-hydroxysteroid dehydrogenase deficiency	¹⁶¹
HSFY2	Heat Shock Transcription Factor, Y linked 2	Deletion	Heat shock protein	Azoospermia	^{162*}
Hypac-H4 and Lys12ac-H4	?	Decreased	histone-H4 hyperacetylation (Hypac-H4) and lysine-12 acetylation (Lys12ac-H4)	lower sperm production in mixed atrophy	¹⁶³
IL1B	Interleukin 1, Beta	IL-1beta Taq C-->T polymorphism	Immune responses	oligoasthenoteratozoospermia	¹⁶⁴
IL1RL1	Interleukin 1 Receptor-Llike 1		pleiotropic cytokine	activity of IL-1RA gene decreases along spermatogenic alteration in an inversely related manner with IL-1alpha	¹⁶⁵
INSL3	Insulin-like 3	Substitution	LGR8 ligand Insulin-like hormone	testicular dysgenesis syndrome, cryptorchidism	¹⁶⁶
INSL3	Insulin-like 3	Missense mutation: V18M, R105H, C-19G	Hormone that regulates testicular descent during fetal life	Hypospadias, Cryptorchidism	¹⁶⁷
INSL3	Insulin-like 3	Thr/Thr genotype of Ala60Thr polymorphism	Hormone that regulates testicular descent during fetal life	Susceptibility factor for development of cryptorchidism	¹⁶⁸
INSL3	Insulin-like 3	Three mutations were novel findings (R4H, W69R, and R72K)	Insulin-like factor 3	testicular dysgenesis syndrome	¹⁶⁹
JARID2	Jumonji, AT Rich Interactive Domain 2	SNP (various)	Nuclear protein	Spina bifida	¹⁷⁰
JUND*	Jun D Proto-oncogene	Deletion	proteins that contribute to the AP-1 transcription factor complex	Oligo-asthenoteratozoospermia	¹⁷¹

KAL1	Kallmann Syndrome 1 Sequence	Point/Deletion	neural cell adhesion molecule	Kallmann's syndrome idiopathic HGG	¹⁷²
KAL1	Kallmann Syndrome 1 Sequence	Mutation	neural cell adhesion molecule	Kallmann's Syndrome, cryptorchidism	¹²⁸
KIAA03 77	Histidine Acid Phosphatase Domain Containing 2A	Genomic Deletion at 15q15.3		Deafness-infertility syndrome	⁴⁴
KIT AND KITLG	v-Kit Hardy-Zuckerman 4 Feline Sarcoma Viral Oncogene Homolog/ KIT ligand	single-nucleotide polymorphisms (SNPs)	KIT tyrosine kinase receptor and its ligand KITLG play a role in the survival and proliferation of germ cells	association of the rs3819392 KIT polymorphism with idiopathic male infertility; rs10506957 KITLG polymorphism with infertile patients	¹⁷³
KLHL10	Kelch-Like 10	Missense and splicing mutations	Protein coding	oligozoospermia	¹⁷⁴
KRAS	v-Ki-Ras2 Kirsten Rat Sarcoma Viral Oncogene Homolog	Mutation	Oncogene	Noonan syndrome, cryptorchidism	^{175*}
KRAS (Chromosome 12)	v-Ki-Ras2 Kirsten Rat Sarcoma Viral Oncogene	Activating mutations	Oncogene	Testicular germ cell tumors	¹⁷⁶
LEP	Leptin	Missense	LEPR ligand metabolic hormone	absence of puberty, hypogonadism, absent facial, pubic, and axillary hair, small penis and testes, gynecomastia, low testosterone, obese	¹⁷⁷
LEPR	Leptin Receptor	Substitution	class-1 cytokine receptor	HHG, obese	¹⁷⁸
LHCGR	Luteinizing Hormone/Choriogonadotropin Receptor	nonsynonymous polymorphisms, Single nucleotide polymorphism (SNP) S312N polymorphism in exon 10	G-protein coupled receptor 1	integrity of the luteinizing hormone/chorionic gonadotropin receptor (LHCGR) higher serum LH and FSH Association with spermatogenetic damage	¹⁷⁹
LHCGR	Luteinizing Hormone/Choriogonadotropin Receptor	Mutation	LH receptor	Male pseudohermaphroditism	¹⁸⁰
LHCGR	Luteinizing Hormone/ Choriogonadotropin Receptor	G-->A mutation at position -1 at the intron 10-exon 11 boundary	Hormone receptor	delayed puberty, micropenis, oligospermia	^{181*}
LHCGR/ LHR	Luteinizing Hormone/Choriogonadotropin Receptor	Missense	g-protein coupled receptor	XY pseudohermaphroditism, leydig cell hypoplasia; in less severe- micropenis or	¹⁸²

				hypospadias	
LHCGR/ LHR	Luteinizing Hormone/Choriogon adotropin Receptor	Activating	g-protein coupled receptor	precocious puberty, extremely rapid virilization	¹⁸³
LHCGR/ LHR	Luteinizing Hormone/Choriogon adotropin Receptor	Homozygous deletion of 5kb of exon 10, F194V mutation	Leutinizing hormone receptor	Leydig cell hypoplasia type II, delayed puberty, Male pseudohermaphroditism	¹⁸⁴
LHX3	LIM Homeobox 3	Deletion/Substitution	transcription factor	HGG, micropenis	¹⁸⁵
L-VDCC	L-type Voltage- Dependent Ca ²⁺ Channels	Polymorphisms	L-Type Voltage Dependent Calcium Channel	Predictor of Successful Varicocelectomy	¹⁸⁶
MAMLD 1	Mastermind-like domain containing 1	Missense mutation: 1295T>C, V432A	Transactivates Hes3 promoter, augments testosterone production, SF1 target sequence	Hypospadias	¹⁸⁷ ¹⁸⁸
MAMLD 1	Mastermind-like domain containing 1	Deletion: 325delG, predicted to cause premature stop codon L121X	Transactivates Hes3 promoter, augments testosterone production, SF1 target sequence	Hypospadias	¹⁸⁷ ¹⁸⁸
MAMLD 1	Mastermind-like domain containing	Insertion: CAG-repeat amplification in the second polyglutamine domain	Transactivates Hes3 promoter, augments testosterone production, SF1 target sequence	Hypospadias	¹⁸⁷ ¹⁸⁸
MEI1	Meiosis Defective 1	SNPs T909G A1582G C1791A C2397T C1791A SNP and C2397T SNP in exons 9 and 14	Meiosis defective 1	C1791A SNP and C2397T SNP in exons 9 and 14 associated with azoospermia	¹⁸⁹
MEST	Mesoderm Specific Transcript Homolog	Undermethylation in sperm	Imprinted genets	Oligospermia	¹⁴⁸
mFTR	Methylene Tetrahydrofolate Receptor	Polymorphism C677t	Methylene tetrahydrofolate receptor	Alters effects of folic acid and zinc sulfate on sperm	¹⁹⁰
MID1	Midline 1	Scattered and consist of missense and nonsense mutations, insertions and deletions, either in- frame or causing frameshifts, and deletions of either single exons or the entire MID1 coding region	MID1 protein	X-linked form of Opitz G/BBB syndrome (OS) – includes hypospadias	¹⁹¹
MJD	Machado-Joseph Disease	CAG repeats (longer)	trinucleotide repeat	Azoospermia	¹⁹²
MLH1	MutL Homolog 1	Mutation (Unpublished observation, Lamb)	Mismatch repair enzyme, homologus recombination	recombination frequencies were reduced	¹⁴⁹

MLH3	MutL Homolog 3	Missense (2895T/C, 2531C/T) and (IVS9+66G/A) variants	Mismatch repair	Azoospermia, primary meiotic arrest	¹⁹³
MNX1/ HLXB9	Motor Neuron and Pancreas Homeobox 1	c.584delA, p.H195fsX28 truncated mutation	Homeobox gene	Spina bifida (erectile dysfunction)	^{194*}
MSY2	Y Box Protein 2	Polymorphisms	a germ-cell-specific member of the Y-box family of DNA-/RNA-binding proteins, functions as a coactivator of transcription	impaired spermatogenesis	¹⁹⁵
MT-ATP6	mitochondrially encoded ATP synthase 6	Substitution/Missense	Mitochondrial ATP synthase	Varicocele and oligoasthenozoospermia	¹⁹⁶
MT-ATP8	mitochondrially encoded ATP synthase 8	Substitution/Missense	Mitochondrial ATP synthase	Varicocele and oligoasthenozoospermia	¹⁹⁶
MT-CO1	Mitochondrial cytochrome oxidase 2	Substitution/Missense/D elition	Cytochrome oxidase I, 2, ,	Varicocele and oligoasthenozoospermia	¹⁹⁶
MT-CO2	Mitochondrial cytochrome oxidase I	Substitution/Missense	Mitochondrial genes,	Varicocele and oligoasthenozoospermia	¹⁹⁶
mtDNA	Mitochondrial DNA	Multiple deletions	?	Male infertility	¹⁹⁷
mtDNA	Mitochondrial DNA	Deletion 4977-bp	Mitochondrial mutation	Asthenozoospermia, oligospermia, infertility	¹⁹⁸
MTHFR	Methylenetetrahyd folate Reductase	677C-->T polymorphism, 80A-->G (H27R) polymorphism, 1298 A>C polymorphism, R293H	Folate metabolism	Spina bifida (erectile dysfunction)	^{199*} ²⁰⁰ ²⁰¹ ²⁰² ²⁰³ ^{204*} ²⁰⁵ ²⁰⁶ ²⁰⁷ ²⁰⁸ ²⁰⁹ ²¹⁰ ²¹¹ ²¹² ²¹³ ²¹⁴ ²¹⁵
MTHFR	Methylenetetrahyd folate Reductase	677C->T polymorphism	Folate metabolism	Exstrophy/epispadias	^{199*}
MTHFR	Methylenetetrahyd folate Reductase	677TT genotype	Folate metabolism	azoospermia	²¹⁶
MTHFR and DNMT3 b	Methylenetetrahyd folate and DNA Methyltransferase 3 beta Reductase	Polymorphism\case study	DNA synthesis and de novo methylation	Astehtenozoospermia	¹⁴⁶

MTHFR, MS and MTRR	Methylenetetrahydr ofolate Reductase, Methionine Synthase, MS Reductase	MTHFR C677T, MS A2756G and MTRR A66G	folate metabolism enzymes plays critical role in DNA synthesis and methylation	MTHFR C677T, MS A2756G and MTRR A66G genotypes were independently associated with male infertility	²¹⁶
mtIQ1	Motif IQ1	Down-regulation	Regulation of spermatogenesis and sperm maturation	cryptorchidism	²¹⁷
MT-ND4	Mitochondrially Encoded NADH Dehydrogenase 4	missense mutation C11994T	Mitochondrial function	Oligoasthenozoospermia	²¹⁸
MTR	Methionine Synthase	2756 AG polymorphism	Homocysteine metabolism	Spina bifida	²¹⁹ ²²⁰ ²²¹ ²¹⁴
MTR	Methionine Synthase	2756GG genotype	Folate metabolism	azoospermia	²¹⁶
MTRNR1	Mitochondrially encoded 12S RNA	A1555G substitution	Mitochondrial function	Exstrophy/epispadias	^{222*}
MTRR	Methionine Synthase Reductase	66A>G polymorphism	Homocysteine remethylation	Spina bifida (erectile dysfunction)	²²³ ²²¹ ²²⁴ ²¹³ ²²⁰ ²¹⁹
MTRR	Methionine Synthase Reductase	66GG genotype	Folate metabolism	oligoasthenoteratozoospermia	²¹⁶
NALP14	NACHT, Leucine Rich Repeat and PYD containing 14	Missense/Nonsense	cytoplasmic protein(part of apoptotic pathway)	severe oligozoospermia to azospermia	²²⁵
NANOG	Nanog Homeobox	Overexpression	Transcription factor related to pluripotency in embryonic stem cells	Testicular CIS, intratubular germ-cell neoplasia unclassified (ITGCNU), seminoma	²²⁶
Nat1	N-acetyltransferase 1	C1095A polymorphism	activation and deactivation of arylamine and hydrazine compounds	Spina bifida (erectile dysfunction)	²²⁷
NCAM1	Neural Cell Adhesion Molecule1	SNP rs2298526	Cell adhesion	Spina bifida (erectile dysfunction)	²²⁸
ND4	NADH Dehydrogenase Subunit 4	missense mutation C11994T	Mitochondrial gene	oligoasthenozoospermia in men from India	
NLRP14	NLR Family, Pyrin Domain Containing 14		member of the NACHT nucleoside triphosphatase family;	spermatogenic failure	²²⁵
NR0B1 encoding DAX1 on chromos ome	Nuclear Receptor Subfamily 0, Group B, Member 1	Duplication: 637kb tandem duplication containing DAX1 gene, 4 MAGEB genes, CXorf21, GK and part of MAP3K7IP3 gene	DAX1 is a dosage sensitive gene responsible for gonadal dysgenesis	Isolated gonadal dysgenesis	^{229*}

Xp21.2					
NR0B1 encoding DAX1 on chromosome Xp21.2	Nuclear Receptor Subfamily 0, Group B, Member 1	257kb deletion upstream of DAX1	DAX1 regulatory sequences	Isolated gonadal dysgenesis	^{230*}
NR5A1 (Sf1)	Nuclear Receptor Subfamily 5, Group A, Member 1	Multiple mutations: missense, nonsense, frameshift , polymorphism	Nuclear receptor TF SF1 (Steroidogenic factor 1)	Susceptibility factor for development of cryptorchidism, gonadal dysgenesis	^{231,2} ³² ²³³ ²³⁴ ^{235*} ^{236*} ²³⁷
NROB1/ AHC	Nuclear receptor subfamily 0, group B, member 1	Expression level	nuclear hormone receptor superfamily of transcription factors	Abnormal spermatogenesis in the human testis, and Sertoli cell-only syndrome and maturation arrest, adrenal hypoplasia congenita	²³⁸
NROB1/ AHC	nuclear receptor subfamily 0, group B, member 1	Duplication	Transcription factor	XY-sex reversal	²³⁹
NROB1/ AHC	nuclear receptor subfamily 0, group B, member 1	Nonsense/Frameshift/ Deletion	Transcription factor	Failure to enter puberty, HHG, disorganized testis cords	²⁴⁰
nuclear protamine ratio (P1/P2)	Nuclear Protamine Ratio (P1/P2)	variable length repeat (VLR), GAn, in the P2 5' region	protamine	Infertility	²⁴¹
OAZ3	Ornithine Decarboxylase Antizyme 3		antizyme that plays a role in cell growth and division by regulating the biosynthesis of polyamines	-239 A/G in the promoter and 4280 C/T, a missense polymorphism in exon 5, may show evidence of association with male infertility	²⁴²
p57kip2	Kinesin Motor Domain Protein		KIP family cyclin-dependent kinase (Cdk) inhibitor	meiotic progression of early spermatocytes and cell cycle arrest and differentiation of spermatids	²⁴³
PATZ1	POZ (BTB) and AT Hook Containing Zinc Finger	Up-regulation and mis-localization	Zinc finger protein that acts as transcriptional repressor; role in gametogenesis	Testicular germ cell tumors	²⁴⁴
PAX3	Paired Box Gene 3	T-1186C (rs16863657), frameshift, and TCTCCGCC	Transcription factor	Spina bifida (erectile dysfunction)	²⁴⁵ ²⁴⁶

PCYT1A	Phosphate cytidylyltransferase 1	rs939883 SNP	Phosphatidylcholine synthesis	Spina bifida (erectile dysfunction)	²⁴⁷
PDGFRA	platelet-derived growth factor receptor alpha	various haplotypes	Growth factor receptor	Spina bifida (erectile dysfunction)	²⁴⁸ ²⁴⁹
PDIA3 /ERp57	Protein Disulfide Isomerase Family A	Decreased expression	human sperm acrosome proteins, which play a critical role in gamete fusion	Infertility, decreased fertilization capability	²⁵⁰
PEMT	Phosphatidylethanol amine N-methyltransferase	Polymorphisms (various)	Amino acid metabolism	Spina bifida (erectile dysfunction)	²⁵¹
PHGPx, the product of gpx-4,	Phospholipid hydroperoxide glutathione peroxidase	No expression	selenoprotein in sperm and is essential for hydroperoxide detoxification, formation of the mitochondrial capsule, and chromatin condensation	Oligospermia	²⁵²
PLOD1	Procollagen-Lysine 1, 2-Oxoglutarate 5-Dioxygenase	Missense	glycoprotein hormone	pubertal delay, low testosterone, small testes, and arrested spermatogenesis	²⁵³
POR	P450 Oxidoreductase	G539R Mutation	Electron donating redox partner of P450c17	CAH 17alpha-hydroxylase/ 17,20 lyase deficiency	^{254*}
POU5F1	POU Domain, Class 5, Transcription Factor 1	Overexpression	Transcription factor related to pluripotency in embryonic stem cells	Gonadoblastoma	⁶¹
POU5F1	POU Domain, Class 5, Transcription Factor 1	Overexpression and aberrant localization in the cytoplasm and nuclei of cells	Transcription factor	Seminoma	²⁵⁵
PRKAR1A	protein kinase, cAMP-dependent regulatory, type I, alpha	Haploinsufficiency	Transduction of cAMP signaling	structural defects in mature sperm and reduced fertility	^{256*} [*]
PRM 1	Protamine 1	transversion c.102G>T , c.119G>A, p.Cys40Tyr missense mutation, , variants both 5' and 3' to the PRM1 open-reading frame	condensing the spermatid genome into a genetically inactive state, arginine-rich DNA-anchoring domains	oligozoospermia associated with increased sperm DNA fragmentation, severe oligoasthenozoospermia, spermatogenesis	²⁵⁷
PROKR2	Prokineticin receptor 2	Missense mutation in exon 2: T820A (Val274Asp).	G protein-coupled receptor	Kallmann's Syndrome, cryptorchidism	²⁵⁸
PROP1	PROP paired-like homeobox 1	Missense/Deletion	transcription factor	short stature, gonadotropin deficiency, absent	²⁵⁹

				puberty	
Protein phosphatase PP1 gamma 2	Protein phosphatase PP1 gamma 2	Decreased activity	serine/threonine phosphatase (PP1)	Decreased motility	²⁶⁰
PTBP2	polypyrimidine tract binding protein 2	polymorphisms	Control of the assembly of splicing-regulatory proteins	male infertility	²⁶¹
PTPN11	protein tyrosine phosphatase, non-receptor type 11	Missense mutation - exons 7, 12 or 13 of the PTPN11 gene	signaling molecules	Leopard syndrome, cryptorchidism	²⁶²
PTPN11	protein tyrosine phosphatase, non-receptor type 11	Gain of function mutation	signaling molecules	Noonan syndrome, cryptorchidism	^{175*}
PWCR	Prader-Willi syndrome chromosome region	Deletion/Imprinting	multiple genes	Prader-Willi syndrome, HHG, incomplete pubertal development, small testes, cryptorchidism	²⁶³
RAF1	v-raf-1 murine leukemia viral oncogene homolog 1	Missense mutation	MAP kinase kinase kinase (MAP3K), which functions downstream of the Ras family of membrane associated GTPases	Leopard syndrome, cryptorchidism	²⁶²
RBMX and RBMXL 9	RNA-binding-motif on the X chromosome and its like sequence on chromosome 9	deletions in or around RBMX and variants of RBMXL9		Association with non-obstructive azoospermia	²⁶⁴
RBMLX 2/ HNRNP G-T	RNA Binding Motif Protein, X-Linked-like 2	Various SNP	Nucleic acid binding	Azoospermia	²⁶⁵
RBMY1	RNA binding motif protein, Y-linked, family 1, member A1	Deletion	found in the AZFb azoospermia factor region of chromosome Y; role in spermatogenesis	Sertoli cell only	²⁶⁶
REG1	REGENERATING ISLET-DERIVED 1-ALPHA	Increased expression	Reg I secretory protein	Testicular cancer (seminoma)	²⁶⁷
RFC1	Reduced folate carrier 1	genotype G80/G80	Folate metabolism	Spina bifida	²⁶⁸
RSPO1	R-spondin homolog (<i>Xenopus laevis</i>)	Insertion G896 Deletion of 2,752 bp (inc. exon4) Homozygous 286+1G-A transition	R-Spondin family member 1; secreted activator protein	Sex reversal	²⁶⁹
RXFP2/ LGR8/ GREAT	Relaxin/Insulin-like Family Peptide Receptor 2	Missense	g-protein coupled receptor	cryptorchidism	²⁷⁰
RXFP2/ LGR8/G	Relaxin/Insulin-like Family Peptide	Missense mutation: T222P	G-protein linked receptor for INSL3	Cryptorchidism	²⁷¹

REAT	Receptor 2				
SABP	secretory actin-binding protein	Increased expression	localized on the sperm tail, mainly in the midpiece of the tail	asthenozoospermia or oligoasthenoteratozoospermia	²⁷²
SALL1	sal-like 1 (Drosophila)	frameshift	Transcription factor	Posterior urethral valve (Townes-Brocks syndrome)	^{273*}
SDHA	succinate dehydrogenase complex, subunit A, flavoprotein (Fp)	SDHA SNP c.456+32G>A	subunit of succinate dehydrogenase/complex II of the respiratory chain	SDHA SNP c.456+32G>A is associated with impairment of sperm production	²⁷⁴
SHBG	sex hormone-binding globulin	SHBG(TAAAA)n allele with 6-10 repeats	Androgen binding	Association of short SHBG alleles with higher sperm concentration	²⁷⁵
SIM1	single-minded homolog 1 (Drosophila)	Deletion	transcription factor	Prader-Willi-like Syndrome, HHG	²⁷⁶
SOS1	son of sevenless homolog 1 (Drosophila)	Mutation	?	Noonan syndrome, cryptorchidism	^{175*}
SOX17	SRY (sex determining region Y)-box 17	Overexpression	Master regulator of cell differentiation	Testicular CIS and seminoma	²⁷⁷
SOX2	SRY (sex determining region Y)-box 2	Missense/Nonsense Frameshift/Deletion	transcription factor	Anophthalmia-Esophageal-Genital Syndrome, cryptorchidism, hypospadias and micropenis	²⁷⁸
SOX2	SRY (sex determining region Y)-box 2	Overexpression	Transcription factor related to pluripotency in embryonic stem cells	Testicular embryonal carcinoma	²⁷⁷
SOX9	SRY (sex determining region Y)-box 9	Nonsense/Inactivating	DNA-binding protein	XY-sex reversal	²⁷⁹
SP1	Sp1 transcription factor		Transcription factor, a zinc finger protein	Germ cell development and differentiation	²⁸⁰
SPAG16	sperm associated antigen 16	Heterozygous mutation affecting exon 13 Frameshift c.[1464–1465insC; 1469–1470insA] (p.F489LfsX46).	Axonemal protein: orthologue of the Chlamydomonas rheinhardtii central apparatus protein PF20	Fertile, but reduced stability of proteins of the central apparatus of the sperm tail: two men Truncated Protein	²⁸¹
SPATA12	spermatogenesis associated 12	Decreased expression	Maintain the cell in a differentiated state and/or to suppress cell proliferation	cryptorchidism	²⁸²
SPATA16	spermatogenesis associated 16		human testis-specific Golgi protein	spermatogenic arrest and Sertoli cell-only syndrome	²⁸³
SPATA16	spermatogenesis associated 16	Homozygous mutation G848A	Spermatogenesis specific gene	Globozoospermia in 3 brothers	²⁸⁴

SRD5A	steroid 5-alpha-reductase 1	Point/Substitution	isoenzyme	ambiguous external genitalia, complete to partial virilization	²⁸⁵
SRY	sex determining region Y	Point/Deletion/ Frameshift	transcription factor	Swyer syndrome XY-sex reversal gonadal dysgenesis	²⁸⁶
SRY	sex determining region Y	Point mutations within HMG (homeobox) region causing missense/nonsense mutations	Sex-determining region of the Y chromosome	Gonadal dysgenesis	^{287*}
SRY	sex determining region Y	Deletions within HMG (homeobox) region	Sex-determining region of the Y chromosome	Gonadal dysgenesis	²⁸⁸
SRY	sex determining region Y	Familial missense mutation: S3L	Sex-determining region of the Y chromosome	Gonadal dysgenesis	^{289*}
SRY	sex determining region Y	Frameshift mutation within HMG box: single nt insertion at codon 89 causing premature stop codon at 103	Sex-determining region of the Y chromosome	Gonadal dysgenesis	^{288*}
SRY	sex determining region Y	Deletion	Sex-determining region of the Y chromosome	Gonadal dysgenesis	²⁹⁰
SRY	sex determining region Y	Missense mutation upstream of HMG box: E38G	Sex-determining region of the Y chromosome	Gonadal dysgenesis	²⁹⁰
SRY	sex determining region Y	Missense mutation upstream of HMG box: X387Y	Sex-determining region of the Y chromosome	Gonadal dysgenesis	²⁹⁰
SRY promoter	sex determining region Y	three base pair deletion in one of the Sp1 binding sites	SRY promoter	XY Gonadal dysgenesis	^{291*}
StAR	steroidogenic acute regulatory protein	Missense/Deletion/ Frameshift	Mitochondrial mitochondrial	congenital lipoid, et al. XY severely undervirilized impaired sex steroid production	²⁹²
STRC	Stereocilin	Genomic Deletion at 15q15.3		Deafness-infertility syndrome	⁴⁴
SYCP3	Synaptonemal complex protein 3	heterozygous 1-bp deletion	Synaptonemal complex protein	azoospermia with maturation arrest	²⁹³
SYCP3/S YCP1	Synaptonemal complex protein 3 and 1		synapsis	meiotic arrest, azoospermic, altered gametogenesis	¹⁴⁹
T mtDNA Haplotypes		Polymorphism	Oxidative Phosphorylation System	Asthenozoospermia	²⁹⁴
TAF7L	TAF7-like RNA polymerase II	sequence variant in exon 13	transcription regulation factors	Possible association with spermatogenic failure	²⁹⁵
T-box 3	TBX3	nonsense mutation (A817T, K273X)	transcriptional repressor	Micropenis	²⁹⁶

TCN2	Transcobalamin II	776C > G polymorphism, 777 CG polymorphism	Vitamin metabolism	Spina bifida (Erectile Dysfunction)	²⁹⁷ / ₂₁₉
Tekton-1	TEKT1	Mutation (A229V)	Axonemal protein	Isolated non-syndromic asthenozoospermia: case report	¹⁰⁷
TFT	Transcription factor T	TIVS7 polymorphism	Transcription factor	Spina bifida	²⁹⁸ / ₂₉₉
TGIF2L X	TGFB-induced factor homeobox 2-like, X-linked	mRNA levels	Homeobox gene, transcriptional regulatory protein	No TGIFLX gene expression in testes of nonobstructive azoospermia patients	³⁰⁰
TRIM37	Tripartite motif-containing 37	Frameshift	peroxisomal protein	Mulibrey nanism, HHG	³⁰¹
TSPY	testis-specific protein, Y-linked	Copy number variation	situated in the MSY (male-specific) region of the Y chromosome	Significantly higher number of TSPY copies was found in infertile men	³⁰²
TSPY	testis-specific protein, Y-linked	Increased expression	Y-encoded testis-specific protein	Gonadoblastom, CIS, ITGCNU, and seminoma	¹¹⁰ / ₃₀₃
TSSK	Testis specific serine/threonine kinase	SNP c.-155C>G and c.765C>A	specific kinase with exclusive expression in testis and involvement in spermatogenesis	single nucleotide polymorphisms c.-155C>G and c.765C>A found only in infertile patients presenting azoospermia or severe oligospermia	³⁰⁴
TSSK4	Testis-specific serine kinase 4	4 single nucleotide polymorphisms	Spermatogenesis	Infertility in Chinese men presenting severe oligozoospermia to azoospermia	³⁰⁴
TXNDC 3	Thioredoxin domain containing 3 (spermatozoa)	Nonsense Mutation (p.Leu426X) and a Common Intronic Variant (c.271–27C>T)	protein disulfide reductases	Primary Ciliary Dyskinesia and male infertility	³⁰⁵
UBE2B	ubiquitin-conjugating enzyme E2B	5 substitutions, SNPs	encodes ubiquitin conjugating enzyme, which is involved in DNA repair	azoospermic, oligoasthenoteratozoospermic and oligoasthenozoospermic	³⁰⁶
UBE2B	ubiquitin-conjugating enzyme E2B	CGG deletions in the promoter region	E2 ubiquitin-conjugating enzyme required for post-replicative DNA damage repair	Deletions associated with increased binding affinity for SP1 and potentially required for alteration of UBE2B gene expression	³⁰⁷
UCP2	uncoupling protein 2	3' untranslated region deletion homozygous genotype (256/256) and A55V homozygous (Val/Val) genotype	mitochondrial membrane transporter gene	Spina bifida (Erectile Dysfunction)	³⁰⁸

UPS9Y	ubiquitin specific protease 9, Y chromosome	Deletion 4-bp deletion in the splice-donor site of USP9Y intron 7		Sertoli cell only	³⁰⁹ , ³¹⁰ , ³¹¹ ,
USP26	ubiquitin-specific protease 26	single nucleotide polymorphisms	a testis-specific and probably involved in the degradation of proteins	Mutations in this gene might be associated with male infertility	³¹²
USP26	ubiquitin specific peptidase 26	polymorphisms, GR/GR deletion		abnormal Spermatogenesis	¹⁰¹
UTP14c	U3 small nucleolar ribonucleoprotein, homolog C	Substitution/Nonsense	retroposon active retroposon, found within a widely expressed, putative glycosyl transferase-containing gene, GT8, on human chromosome 13	severe oligozoospermia to azoospermia, mutation in nonobstructive, azoospermic/severely oligospermic males patients that introduces an in-frame stop codon truncating the UTP14c protein near the carboxyl terminus	³¹³
UTY	ubiquitously transcribed tetratricopeptide repeat gene, Y-linked	Deletion	Ubiquitously transcribed tetratricopeptide repeat gene on Y chromosome	Azoospermia, Deleted together with other AZFa genes	¹⁰²
VANGL1	vang-like 1	V239I, R274Q, and M328T	Cell orientation during morphogenesis	Spina bifida (Erectile Dysfunction)	³¹⁴
WT1	Wilms Tumor 1	Splice mutation – intron 9	Transcription factor, tumor suppressor, sex determination, essential for the maintenance of Sertoli cells and seminiferous tubules in the developing testes, SOX9 regulation	Gonadal dysgenesis, Frasier Syndrome, germ cell tumors (esp. gonadoblastoma), hypospadias	³¹⁵ ³¹⁶
WT-1	Wilms Tumor 1	Inactivating	transcription factor	Frasier syndrome, intersex, gonadoblastoma	³¹⁷
WT-1	Wilms tumor 1	Dominant negative	transcription factor	Denys-Drash syndrome pseudohermaphroditism, ambiguous genitalia	³¹⁸
XPC	Xeroderma Pigmentosum, Complementation Group C	Ala499Val (C>T) polymorphism	Encodes protein: xeroderma pigmentosum, complementation group C	azospermia	³¹⁹
XRCC1	X-ray repair cross-complementing group 1	polymorphism	DNA repair genes	Association of polymorphisms with idiopathic azoospermia in a selected Chinese population	³²⁰

YBX2	Y Box Binding Protein 2	SNP	nucleic acid-binding protein	abnormal spermatogenesis	³²¹
YBX2	Y box binding protein 2	single nucleotide polymorphisms	Contrin, a Y box family of nucleic acid binding proteins	severe defects in spermatogenesis, including azoospermia or severe oligozoospermia, and protamine deregulation.	¹⁹⁵
ZNF214	Zinc Finger Protein 214	Insertion/Missense	Zinc finger protein	Beckwith-Wiedemann syndrome; Impaired spermatogenesis/ cryptorchidism	³²²
ZNF215	Zinc Finger Protein 215	Substitution/Missense	Zinc finger protein	Beckwith-Wiedemann syndrome; Impaired spermatogenesis/ cryptorchidism	³²²

Table 2: Chromosome Regions

CHROMOSOME	TYPE OF MUT	PHENOTYPE	REF
45,X[7]/46,X,psu dic (Y)(pter->q11.2::q11.2-->pter)	Pseudodicentric Y Deletion of DAZ and RBM1	Early meiotic arrest	³²³
45,XY,-14,der(18)t(14;18)(q11;p11.3)	Complex chromosomal translocation	Infertility	³²⁴
45,X/46,XY	Mosaicism	Micropenis	^{325*}
46 XY, 47 XY + 18 mosaic	Trisomy	Morphological and meiotic spermatogenetic impairment	^{326*}
46,X,der(Y;12;15){t(Y;12)q11.23;q21.2); t(inv(12);15) {(p11.2q21.2);q13};t(15;Y)(q13;q11.23)}	Complex Chromosome Rearrangement	Azoospermia	³²⁷
46,XY,t(19;22) and 46,XY,t(17;21)	reciprocal translocations	Infertility	³²⁸
46,XY,t(6;21)(p21.1;pl3)	Translocation	Oligoasthenozoospermia or Azoospermia	³²⁹
46,XY,inv(6)(p12q21)	inversion	Congenital bilateral absence of the vas deferens, late maturation arrest of spermatogenesis	³³⁰
[46,XY,inv(6)(p12q21)] 5T CFTR	Pericentric inversion	Testis atrophy, azoospermia, congenital bilateral absence of the vas deferens, Late maturation arrest	³³⁰
46,X,t(Y;1)(q12;q12)	Reciprocal translocation	Azoospermia	³³¹
46,Y,t(X;20)(q10;q10), t(2;4;8)(q23;q27;p21)*	Translocation significant chromosome abnormality	Severe oligozoospermia Infertility	³³² ³³³
t(4;6)(q12;p23) MBOAT1	Translocation, gene disruption	Azoospermia, Dauwerse-Peters Syndrome,	³³⁴
t(5;12) (p15.1; q21) balanced chromosomal translocation	?	Teratozoospermia (Tail Stump Syndrome) in two brothers: case report	³³⁵
t(5;12) (p15.1; q21)	Balanced chromosomal translocation	Tail stump syndrome in two brothers	^{335**}
t(6;21)(p21.1;p13) *	Familial (three brothers)	meiosis in spermatogenesis and lead to infertility	³²⁹
t(7;16)(q21.2;p13.3)	reciprocal translocation	oligoasthenoteratozoospermia	^{336**}
t(8;13) reciprocal translocation	Translocation	Azoospermia	¹⁴⁹
t(8;15) (q22;p11)*	equilibrated reciprocal autosomal translocation	Infertility in 3 men	^{337*}
t(10;15) (q26;q12)	Balanced Translocation	High level of sperm aneuploidies, diffuse structural abnormalities	³³⁸
t(17; 22) (q11; q12) *	Balanced	Oligoteratozoospermia	³³⁹

	translocatin		
t(X;3) (q26;q13.2)		Familial azospermia	³⁴⁰
t(X;18)(q11;p11.1)	Translocation	oligoasthenoteratozoospermia	³⁴¹ **
All chromosomes	Complete triploids (69XXY)	Micropenis	³⁴² * ³⁴³ *
Chromosome 1	del(1)(q24q25.3)	Spina bifida (erectile dysfunction)	³⁴⁴ *
Chromosome 1	Del(1)(q25q32)	Prune belly syndrome, cryptorchidism	³⁴⁵ *
Chromosome 1	1p21.1 deletion	Exstrophy/epispadias	³⁴⁶
Chromosome 1q41-44	Unknown-Linkage study	Posterior urethral valve, Prune belly syndrome, cryptorchidism	³⁴⁷ *
Chromosome 2	2q36 deletions	Spina bifida (erectile dysfunction)	³⁴⁸ * ³⁴⁹ *
Chromosome 2	der(2)inv(2)(q13q21)inv(2) (q21q24.2)ins(2)(q24.2q33q35)	Spina bifida (erectile dysfunction)	³⁵⁰ *
Chromosome 2	Trisomy	Spina bifida (erectile dysfunction)	³⁵¹ *
Chromosome 2	2p23-2pter trisomy	Micropenis	³⁵²
Chromosome 2q36-q37	Decreased copy number and expression	Non-seminomas	³⁵³
Chromosome 3	Proximal 3q microdeletion (2.5 Mb de novo deletion on q13.11q13.12) with deletion of ALCAM and CBLB genes	Cryptorchidism	³⁵⁴ *
Chromosome 3	der(3)del(3)(p26) dup(3)(p26p21.3)	Spina bifida (erectile dysfunction)	³⁵⁵ *
Chromosome 3	ins(3)(pter --> p25::q27 --> q21::p25 --> qter)	Spina bifida (erectile dysfunction)	³⁵⁶ *
Chromosome 3	3q25.3 --> q29	Spina bifida (erectile dysfunction)	³⁵⁷ *
Chromosome 3	del(3)(q12.2q13.2)	Exstrophy/epispadias	³⁵⁸ *
Chromosome 4	2.34 Mb terminal 4p deletion	Wolf-Hirschhorn syndrome, Hypospadias	³⁵⁹ *
Chromosome 4	Deletion of 4q33 [46,XY,del(4)(q33)]	4q deletion syndrome, hypospadias	³⁶⁰ *
Chromosome 4	Partial trisomy 4(q31.3qter) due to unbalanced segregation of a maternal translocation (4;5)(31.3;p15.1)	Cryptorchidism, multiple congenital defects	³⁶¹ *

Chromosome 4q22	Overexpression	Spermatocytic seminomas	³⁵³
Chromosome 5	5q duplication	Micropenis	^{362*}
Chromosome 5	Distal 5p deletion	Azoospermia	^{363*}
Chromosome 5q23.2	Overexpression	Spermatocytic seminomas	³⁵³
Chromosome 6	6q interstitial deletion with breakpoints at q24.3-q25.2	Cryptorchidism	^{364*}
Chromosome 6	6q25.3 deletion	Spina bifida (erectile dysfunction)	^{365*}
Chromosome 6	6q deletion	Prune belly syndrome, cryptorchidism	^{366*}
Chromosome 6	6q deletion	Micropenis	^{367*}
Chromosome 6	Trisomy 6q25 to 6qter	Micropenis	^{368*}
Chromosome 6q24	Decreased copy number and expression	Non-seminomas	³⁵³
Chromosome 6p21.3	Gene deletion: produces haplotype with intron 2 splice mutation (IVS2-12A/C>G) + 707-714 deletion	CAH 21-hydroxylase deficiency	³⁶⁹ ³⁷⁰
Chromosome 6p21.3	Gene deletion: produces CYP21P/CYP21 chimeric fusion gene	CAH 21-hydroxylase deficiency	³⁷⁰ ³⁷¹
Chromosome 6p21.3	Gene duplication + gene deletion: (duplication of 111 bases from codons 21 to 57 inserted at codon 58 in exon 1 of the CYP21 gene) + (deletion of the CYP21P, XA, RP2, and C4B genes)	CAH 21-hydroxylase deficiency	^{372*}
Chromosome 7	7q36-qter deletion	Spina bifida (erectile dysfunction)	^{373*}
Chromosome 7	partial trisomy 7q	Micropenis	^{374*}
Chromosome 7	Paracentric inversion of chromosome 7(q22-31)	Azoospermia	^{375*}
Chromosome 7q32.2-q36.1	Susceptibility locus	Hypospadias	³⁷⁶
Chromosome 8	del(8)(q11.23q13.3).	Micropenis	^{377*}
Chromosome 9	Trisomy	Spina bifida (erectile dysfunction)	^{378*} ^{379*}
Chromosome 9	Pericentric	Prune belly syndrome,	³⁸⁰

	inversions and translocations	cryptorchidism	³⁸¹
Chromosome 9	Inversion	Prune belly syndrome, cryptorchidism	^{382*}
Chromosome 9	Pericentric inversions	azoospermic	³⁸³
Chromosome 9p21	Overexpression	Spermatocytic seminomas	³⁵³
Chromosome 9p24	Deletion	Gonadal dysgenesis	³⁸⁴
Chromosome 9q34.3	Unknown-linkage study	Micropenis	³⁸⁵
Chromosome 10	10q25.3 (unknown)	Spina bifida (erectile dysfunction)	³⁸⁶
Chromosome 10	Ring chromosome	Posterior urethral valve	^{387*}
Chromosome 10	10q26.1 deletion	Posterior urethral valve	^{388*}
Chromosome 11	46,XY (Female), del(11)(p12p14.1) including WT1 and PAX6	Gonadal dysgenesis – complete sex reversal, WAGR syndrome	^{389*}
Chromosome 11	Deletion at 11p13 (includes WT1 and PAX6 genes)	WAGR contiguous gene deletion syndrome, cryptorchidism	^{389*}
Chromosome 11	11q deletion	Micropenis	^{390*}
Chromosome 11	11q duplication	Micropenis	^{391*}
Chromosome 11	11q trisomy (11q12.1 to 11q23.2)	Micropenis	^{392*} ^{393*}
Chromosome 11	11q trisomy (11q23.2 to 11qter)	Micropenis	³⁹⁴
Chromosome 11p11	Unknown	Posterior urethral valve, Prune belly syndrome, cryptorchidism	^{347*}
Chromosome 12	Gain of 12p	Testicular germ cell tumors	³⁹⁵
Chromosome 12	Amplification of 12p	Testicular germ cell tumors	³⁹⁶
Chromosome 12	Ring chromosome	Azoospermia	^{397*}
Chromosome 12	Ring chromosome 12	Oligospermia	^{397*}
Chromosome 13	Deletion of 9.5-Mb interval of 13q33.3-q34 delineated by markers D13S280-D13S285; this spans approximately 8% of the chromosome and contains 20 annotated genes (EFNB2 gene?)	Hypospadias and other genital malformations	³⁹⁸ ¹¹¹
Chromosome 13	Trisomy	cryptorchidism	³⁹⁹
Chromosome 13	Trisomy 13	Spina bifida (erectile dysfunction)	⁴⁰⁰

Chromosome 13	13q33-34	Spina bifida (erectile dysfunction)	^{401*}
Chromosome 13	Trisomy	Prune belly syndrome, cryptorchidism	^{402*} ⁴⁰³
Chromosome 14	trisomy 14q32	Spina bifida (erectile dysfunction)	^{404*}
Chromosome 14	Q22.1-22.3 deletion	Micropenis	^{405*}
Chromosome 14	Trisomy	Micropenis	⁴⁰⁶ ⁴⁰⁷ ^{408*}
Chromosome 14	Supernumerary minute ring chromosome 14	Azoospermia	^{409*}
Chromosome 14	supernumerary minute ring chromosome 14	Male infertility, varicocele	⁴⁰⁹
Chromosome 16	Duplication 16q12.1-q22.1	Spina bifida (erectile dysfunction)	^{410*}
Chromosome 18	Trisomy 18p supernumerary marker chromosome (SMC)	cryptorchidism	^{411*}
Chromosome 18	Trisomy	Spina bifida (erectile dysfunction)	^{412*} ^{413*}
Chromosome 18	Trisomy	Prune belly syndrome, cryptorchidism	^{414*} ^{415*}
Chromosome 18	18p deletion	Micropenis	^{416*}
Chromosome 18	18p-	Micropenis	^{417*}
Chromosome 18	ring 18q	hypergonadotrophic hypogonadism	^{418*}
Chromosome 20	Trisomy 20p 46,XY,der(20)(pter --> q13.3::p11.2 --> pter)	cryptorchidism	^{419*}
Chromosome 20	Translocation or duplication	Prune belly syndrome, cryptorchidism	^{382*}
Chromosome 21	Trisomy	Prune belly syndrome, cryptorchidism	^{420*}
Chromosome 21	45,XY,-21/46,XY mosaicism	Micropenis	^{421*}
Chromosome 22	47,XY,+der(22)t(1;22)(q23;q11)	Emanuel syndrome, cryptorchidism	^{422*}
Chromosome 22	Duplication 22q11	Cryptorchidism, symptoms of DiGeorge syndrome	^{423*}
Chromosome 22	Trisomy (22)(q13.1-qter)	Cryptorchidism, multiple congenital defects	^{424*}
Chromosome 22	22q11 deletion	Spina bifida (erectile dysfunction)	⁴²⁵ ⁴²⁶ ⁴²⁷ ⁴²⁸ ⁴²⁹

Chromosome 22	Trisomy 22	Micropenis	^{430*}
Chromosome X	dup(X)q26-q27	Spina bifida, erectile dysfunction	^{431*}
Chromosome X	Duplication in Xp22.31	Wolf-Hirschhorn syndrome, Hypopspadias	^{359*}
Chromosome X	Mosaic: 46,XY[83]/47,XY,+r(X)[17]	Ullrich-Turner Syndrome, cryptorchidism	^{432*}
Chromosome X	47,XXY or 48,XXYY or 48,XXXY or 49,XXXXY	Klinefelter syndrome, cryptorchidism	⁴³³
Chromosome X	48,XXYY	XXYY syndrome, cryptorchidism	⁴³⁴
Chromosome X	Xq28 duplication	cryptorchidism	^{435*}
Chromosome X	Xq duplication (dup(X)(q13.3q24))	Cryptorchidism, multiple congenital abnormalities	^{436*}
Chromosome X	Xq27	TGCT	⁴³⁷
Chromosome X	49,XXXXY	Micropenis	^{438*} ⁴³⁹ ^{440*}
Chromosome X	Ring chromosome	Micropenis	^{441*}
Chromosome X	45,X/46,X,i(Xq)	Gonadal dysgenesis	⁴⁴²
Chromosome X	Ring chromosome lacking XIST locus	Prune belly syndrome, cryptorchidism	^{443*}
Chromosome X	Trisomy X	Exstrophy/epispadias	^{444*}
Chromosome X	47XXY	Klinefelter Syndrome, azospermia	⁴⁴⁵
Chromosome Xp11.21-11.23	susceptibility locus for sex reversal/gonadal dysgenesis	Gonadal dysgenesis	⁴⁴⁶
Chromosome Y	Dicentric: 45, X/46, X, idic (Y) (q11.2)	Hypopspadias, Cryptorchidism	^{447*}
Chromosome Y	48,XXYY	XXYY syndrome, cryptorchidism	⁴³⁴
Chromosome Y	Microdeletions in regions AZFa, AZFb, AZFc or AZFb + c region	cryptorchidism	⁴⁴⁸
Chromosome Y	Gr/gr deletion	Two-fold increased risk of TGCT	⁴⁴⁹ ⁴⁵⁰
Chromosome Y	47XYY	Exstrophy/epispadias	⁴⁵¹
Chromosome Y	Yq deletion	Micropenis	^{452*}
Chromosome Y	47,XY	Micropenis	^{453*}
Chromosome Y	dic(Y)(p11)	Micropenis	^{454*}
Chromosome Y	45,X/46,X,idic(Yp)	Mixed gonadal dysgenesis	⁴⁵⁵
Chromosome Y	Yq11 deletions	Idiopathic oligoazoospermia	⁴⁵⁶ ⁴⁵⁷
Chromosome Y	45,X/46,X,psu dic(Y) (pter-->q11.2::q11.2--	Mixed gonadal dysgenesis	^{458*}

	>pter)		
Chromosome Y	i(Y)(p10)	Azoospermia	^{459*}
Chromosome Y	YqTER deletion	Azoospermia	^{460*}
Chromosome Y	dicentric Yq (p11.32) isochromosome	Azoospermia	^{461*}
Chromosome Y	Dicentric Yp chromosome with 45,X mosaicism	Gonadal dysgenesis	⁴⁶²
Chromosome Y	ring(Y)	True hermaphrodite	^{463*}
Chromosome Y	ring(Y)	Azoospermia	^{464*}
Chromosome Y	Yp11 partial duplication and deletion	Azoospermia	^{465*}
Chromosome Y	q arm microdeletions	asthenozoospermia	⁴⁶⁶
Chromosome Y	satellited Y chromosome q arm (Yqs)	oligoasthenoteratospermia	^{467*}
Chromosome Y	45,X/46,X(r)Y	spermatogenic failure	⁴⁶⁸
Chromosome Y	Inversion	asthenozoospermia	⁴⁶⁶
Chromosomes 1 and 21	t(1;21)(q25;q22)	Micropenis	^{469*}
Chromosomes 1 and 21	t(1;21)(q11;p13)	Azoospermia	^{470*}
Chromosomes 1 and 21	46,XY,t(1;21)(q11; p13)	Azospermia	^{470*}
Chromosomes 1 and 22	t(1;22)(q11;p11)	Azoospermia	^{470*}
Chromosomes 1 and 22	46,XY,t(1;22)(q11; p11)	azospermia	^{470*}
Chromosomes 1 and 6	diploid/tetraploid/t(1;6) mosaicism	Exstrophy/epispadias	^{471*}
Chromosomes 3 and 22	translocation 3;22	oligoasthenoteratospermia	^{472*}
Chromosomes 3, 8, and 16	t (3; 16; 8) (p26; q13; q21.2)	Azoospermia	^{473*}
Chromosomes 4 and 12	t(4;12) (q35.1; q21.2)	Micropenis	^{474*}
Chromosomes 4 and 15	T(4p;-15q+)	Micropenis	^{475*}
Chromosomes 4 and 16	ins(4;16)(q26q28.1 ; q12.1q12.2)	Spina bifida (erectile dysfunction)	^{476*}
Chromosomes 4 and 19	t(4p;-19p or q+)	Micropenis	^{477*}
Chromosomes 5 and 12	t(5;12) (p15.1; q21) translocation	tail stump syndrome	^{335*}
Chromosomes 5 and 17	t(5;17)(p15;p11)	Micropenis	^{478*}
Chromosomes 6 and 11	t(6;11) with breakpoints at 6q15 and 11p15	Oligoazoospermia	^{479*}
Chromosomes 7 and 10	Chromosome 7: 24 cM interval between D7S3056 and D7S3051, chromosome 10: D10S1731	Spina bifida (erectile dysfunction)	⁴⁸⁰
Chromosomes 7 and 16	t(7;16)(q21.2;p13. 3)	Oligoasthenoteratozoospermia	^{336*}

Chromosomes 7 and 8	7q36 deletion and 8q24.3 duplication resulting from a distal 7q/8q translocation	Cryptorchidism, multiple congenital defects	^{481*}
Chromosomes 8 and 13	t(8;13)	Azoospermia	¹⁴⁹
Chromosomes 8 and 9	t(8;9)(p11.2; q13)	Exstrophy/epispadias	⁴⁵¹
Chromosomes 9 and 15	t(9;15)(p10;q10)	Oligoasthenoteratozoospermia	^{482*}
Chromosomes 9 and 15	t(9;15)(p10;q10)	oligoasthenoteratozoospermia	^{482*}
Chromosomes 9 and 22	t(9;22)(q21;q11.2)	Infertility	^{483*}
Chromosomes 10 and 13	unbalanced translocation 10p/13q (karyotype: 46,XY,der(10)t(10;13)(p15.1;q34)(D10S2488-,D13S296+))	MR, growth retardation, multiple congenital malformations and CO	^{484*}
Chromosomes 11 and 22	t(11;22)(q23;q11).	Spina bifida (erectile dysfunction)	^{485*}
Chromosomes 12 and 21	partial trisomy 12q (12q24.32-->qter) and partial monosomy 21q (21q22.2-->ter-->qter)	Micropenis	^{486*}
Chromosomes 13 and 14	45,XY,der(13;14)(q10;q10)	Azoospermia	⁴⁸⁷
Chromosomes 18, X, Y	Altered centromere position	Male infertility	⁴⁸⁸
Chromosomes X and 8	t(X;8)(p22;q11)	Azoospermia	⁴⁸⁹
Chromosomes X and 14	46,Y,t(X;14)(p11.4;p12)	oligospermia	^{490*}
Chromosomes X and 18	t(X;18)(q11;p11.1)	Oligoasthenoteratozoospermia	³⁴¹
Chromosomes X and 19	t(X;19)(q22;q13.3)	Azoospermia	⁴⁸⁹
Chromosomes X and 20	t(X;20)(q10;q10)	Oligozoospermia	^{332*}
Chromosomes X and 22	t(X;22)(q27;q121)	Spina bifida (erectile dysfunction)	^{491*}
Chromosomes Y and 1	(Y;1)(q12;q25)	Azoospermia	⁴⁹²
Chromosomes Y and 1	t(Y;1)(q11.2;p34.3)	Spermatogenic failure	⁴⁹³
Chromosomes Y and 1	t(Y;1)(q12;q12)	Azoospermia	^{331*}
Chromosome Y and 9	9q34.1-qter from unbalanced translocation from Chromosome Y	Exstrophy/epispadias	^{494*}
Chromosomes Y and 13	Yp;13p	Oligozoospermia	^{495*}
Chromosomes Y and 15	(Y;15)(q12;p11).	Azoospermia	⁴⁹⁶
Chromosomes Y and 22	t(Y;22)(q11.2;q11.1)	Azoospermia	^{497*}

1. Bilbao, J.R., Loridan, L., Audi, L., Gonzalo, E. & Castano, L. A novel missense (R80W) mutation in 17-beta-hydroxysteroid dehydrogenase type 3 gene associated with male pseudohermaphroditism. *Eur J Endocrinol* **139**, 330-3 (1998).
2. Peruzzi, L. et al. Low renin-angiotensin system activity gene polymorphism and dysplasia associated with posterior urethral valves. *J Urol* **174**, 713-7 (2005).
3. Kucera, M., Crha, I., Vasku, A., Ventruba, P. & Znojil, V. [Polymorphism of angiotensin converting enzyme (ACE) and TNF-beta genes in men with disorders of spermatogenesis--pilot study]. *Ceska Gynekol* **66**, 313-7 (2001).
4. Christensen, G.L., Wooding, S.P., Ivanov, I.P., Atkins, J.F. & Carrell, D.T. Sequencing and haplotype analysis of the activator of CREM in the testis (ACT) gene in populations of fertile and infertile males. *Mol Hum Reprod* **12**, 257-62 (2006).
5. Huang, M. et al. Involvement of ALF in human spermatogenesis and male infertility. *Int J Mol Med* **17**, 599-604 (2006).
6. Soneda, S. et al. Association of micropenis with Pro185Ala polymorphism of the gene for aryl hydrocarbon receptor repressor involved in dioxin signaling. *Endocr J* **52**, 83-8 (2005).
7. Fujita, H. et al. Characterization of the aryl hydrocarbon receptor repressor gene and association of its Pro185Ala polymorphism with micropenis. *Teratology* **65**, 10-8 (2002).
8. Merisalu, A. et al. The contribution of genetic variations of aryl hydrocarbon receptor pathway genes to male factor infertility. *Fertil Steril* **88**, 854-9 (2007).
9. Watanabe, M. et al. Association of male infertility with Pro185Ala polymorphism in the aryl hydrocarbon receptor repressor gene: implication for the susceptibility to dioxins. *Fertil Steril* **82 Suppl 3**, 1067-71 (2004).
10. Baccetti, B. et al. Gene deletions in an infertile man with sperm fibrous sheath dysplasia. *Hum Reprod* **20**, 2790-4 (2005).
11. Deak, K.L. et al. Analysis of ALDH1A2, CYP26A1, CYP26B1, CRABP1, and CRABP2 in human neural tube defects suggests a possible association with alleles in ALDH1A2. *Birth Defects Res A Clin Mol Teratol* **73**, 868-75 (2005).
12. Kranz, C. et al. Expanding spectrum of congenital disorder of glycosylation Ig (CDG-Ig): sibs with a unique skeletal dysplasia, hypogammaglobulinemia, cardiomyopathy, genital malformations, and early lethality. *Am J Med Genet A* **143A**, 1371-8 (2007).
13. Carre-Eusebe, D. et al. Variants of the anti-Mullerian hormone gene in a compound heterozygote with the persistent Mullerian duct syndrome and his family. *Hum Genet* **90**, 389-94 (1992).
14. Imbeaud, S. et al. A 27 base-pair deletion of the anti-mullerian type II receptor gene is the most common cause of the persistent mullerian duct syndrome. *Hum Mol Genet* **5**, 1269-77 (1996).
15. Toscani, A. et al. Arrest of spermatogenesis and defective breast development in mice lacking A-myb. *Nature* **386**, 713-7 (1997).
16. Scalvini T, M.P., Gambera A, Tardanico R, Biasi L, Scolari F, Gregorini G, Agabiti Rosei E. . Spermatogenic and steroidogenic impairment of the testicle characterizes the hereditary leucine-75-proline apolipoprotein a-I amyloidosis. *J Clin Endocrinol Metab* **May;93(5)**, 1850-3. (2008)

-).
17. Scalvini, T. et al. Infertility and hypergonadotropic hypogonadism as first evidence of hereditary apolipoprotein A-I amyloidosis. *J Urol* **178**, 344-8 (2007).
 18. Peterlin, B., Zorn, B., Volk, M. & Kunej, T. Association between the apolipoprotein B signal peptide gene insertion/deletion polymorphism and male infertility. *Mol Hum Reprod* **12**, 777-9 (2006).
 19. Radpour, R., Rezaee, M., Tavasoly, A., Solati, S. & Saleki, A. Association of long polyglycine tracts (GGN repeats) in exon 1 of the androgen receptor gene with cryptorchidism and penile hypospadias in Iranian patients. *J Androl* **28**, 164-9 (2007).
 20. Garolla, A. et al. Molecular analysis of the androgen receptor gene in testicular cancer. *Endocr Relat Cancer* **12**, 645-55 (2005).
 21. Ferlin, A. et al. Male infertility and androgen receptor gene mutations: clinical features and identification of seven novel mutations. *Clin Endocrinol (Oxf)* **65**, 606-10 (2006).
 22. Dowsing, A.T. et al. Linkage between male infertility and trinucleotide repeat expansion in the androgen-receptor gene. *Lancet* **354**, 640-3 (1999).
 23. La Spada, A.R., Wilson, E.M., Lubahn, D.B., Harding, A.E. & Fischbeck, K.H. Androgen receptor gene mutations in X-linked spinal and bulbar muscular atrophy. *Nature* **352**, 77-9 (1991).
 24. Mifsud, A. et al. Trinucleotide (CAG) repeat polymorphisms in the androgen receptor gene: molecular markers of risk for male infertility. *Fertil Steril* **75**, 275-81 (2001).
 25. Rocha, R.O. et al. The degree of external genitalia virilization in girls with 21-hydroxylase deficiency appears to be influenced by the CAG repeats in the androgen receptor gene. *Clin Endocrinol (Oxf)* **68**, 226-32 (2008).
 26. Okada, H. et al. Genome-wide expression of azoospermia testes demonstrates a specific profile and implicates ART3 in genetic susceptibility. *PLoS Genet* **4**, e26 (2008).
 27. Jagla, M., Kruczak, P. & Kwinta, P. Association between X-linked lissencephaly with ambiguous genitalia syndrome and lenticulostriate vasculopathy in neonate. *J Clin Ultrasound* **36**, 387-90 (2008).
 28. Beleza-Meireles, A. et al. Activating transcription factor 3: a hormone responsive gene in the etiology of hypospadias. *Eur J Endocrinol* **158**, 729-39 (2008).
 29. Liu, B. et al. Estradiol upregulates activating transcription factor 3, a candidate gene in the etiology of hypospadias. *Pediatr Dev Pathol* **10**, 446-54 (2007).
 30. Barlow, C. et al. Atm deficiency results in severe meiotic disruption as early as leptotene of prophase I. *Development* **125**, 4007-17 (1998).
 31. Holyoake, A.J., Sin, I.L., Benny, P.S. & Sin, F.Y. Association of a novel human mtDNA ATPase6 mutation with immature sperm cells. *Andrologia* **31**, 339-45 (1999).
 32. Dieterich, K. et al. Homozygous mutation of AURKC yields large-headed polyploid spermatozoa and causes male infertility. *Nat Genet* **39**, 661-5 (2007).
 33. Kamp, C. et al. High deletion frequency of the complete AZFa sequence in men with Sertoli-cell-only syndrome. *Mol Hum Reprod* **7**, 987-94 (2001).

34. Ferlin, A., Moro, E., Rossi, A., Dallapiccola, B. & Foresta, C. The human Y chromosome's azoospermia factor b (AZFb) region: sequence, structure, and deletion analysis in infertile men. *J Med Genet* **40**, 18-24 (2003).
35. Perrin, J. et al. Meiotic arrest at the midpachytene stage in a patient with complete azoospermia factor b deletion of the Y chromosome. *Fertil Steril* **85**, 494 e5-8 (2006).
36. Ferlin, A. et al. Association of partial AZFc region deletions with spermatogenic impairment and male infertility. *J Med Genet* **42**, 209-13 (2005).
37. Morin, I. et al. Common variant in betaine-homocysteine methyltransferase (BHMT) and risk for spina bifida. *Am J Med Genet A* **119A**, 172-6 (2003).
38. Kempkensteffen, C. et al. Expression of splicing variants of the inhibitor of apoptosis livin in testicular germ cell tumors. *Tumour Biol* **29**, 76-82 (2008).
39. Kostova, E. et al. Association of three isoforms of the meiotic BOULE gene with spermatogenic failure in infertile men. *Mol Hum Reprod* **13**, 85-93 (2007).
40. Choi, J. et al. Alu sequence variants of the BPY2 gene in proven fertile and infertile men with Sertoli cell-only phenotype. *Int J Urol* **14**, 431-5 (2007).
41. King, T.M. et al. The impact of BRCA1 on spina bifida meningomyelocele lesions. *Ann Hum Genet* **71**, 719-28 (2007).
42. Zhoucun, A. et al. The common variant N372H in BRCA2 gene may be associated with idiopathic male infertility with azoospermia or severe oligozoospermia. *Eur J Obstet Gynecol Reprod Biol* **124**, 61-4 (2006).
43. Avidan, N. et al. CATSPER2, a human autosomal nonsyndromic male infertility gene. *Eur J Hum Genet* **11**, 497-502 (2003).
44. Zhang, Y. et al. Sensorineural deafness and male infertility: a contiguous gene deletion syndrome. *J Med Genet* **44**, 233-40 (2007).
45. Jensen, L.E., Etheredge, A.J., Brown, K.S., Mitchell, L.E. & Whitehead, A.S. Maternal genotype for the monocyte chemoattractant protein 1 A(-2518)G promoter polymorphism is associated with the risk of spina bifida in offspring. *Am J Med Genet A* **140**, 1114-8 (2006).
46. Ferlin, A., Moro, E., Rossi, A. & Foresta, C. CDY1 analysis in infertile patients with DAZ deletions. *J Endocrinol Invest* **24**, RC4-6 (2001).
47. Stouffs, K. et al. Do we need to search for gr/gr deletions in infertile men in a clinical setting? *Hum Reprod* **23**, 1193-9 (2008).
48. Zhu, H. et al. Association between CFL1 gene polymorphisms and spina bifida risk in a California population. *BMC Med Genet* **8**, 12 (2007).
49. Dayangac, D. et al. Mutations of the CFTR gene in Turkish patients with congenital bilateral absence of the vas deferens. *Hum Reprod* **19**, 1094-100 (2004).
50. De Braekeleer, M. & Ferec, C. Mutations in the cystic fibrosis gene in men with congenital bilateral absence of the vas deferens. *Mol Hum Reprod* **2**, 669-77 (1996).
51. Disset, A. et al. A T3 allele in the CFTR gene exacerbates exon 9 skipping in vas deferens and epididymal cell lines and is associated with Congenital Bilateral Absence of Vas Deferens (CBAVD). *Hum Mutat* **25**, 72-81 (2005).
52. Tamburino, L., Guglielmino, A., Venti, E. & Chamayou, S. Molecular analysis of mutations and polymorphisms in the CFTR gene in male infertility. *Reprod Biomed Online* **17**, 27-35 (2008).

53. Aramaki, M. et al. Phenotypic spectrum of CHARGE syndrome with CHD7 mutations. *J Pediatr* **148**, 410-4 (2006).
54. Volcik, K.A. et al. Evaluation of the Cited2 gene and risk for spina bifida and congenital heart defects. *Am J Med Genet A* **126A**, 324-5 (2004).
55. Tian, Q., Frierson, H.F., Jr., Krystal, G.W. & Moskaluk, C.A. Activating c-kit gene mutations in human germ cell tumors. *Am J Pathol* **154**, 1643-7 (1999).
56. Sakuma, Y. et al. Mutations of c-kit gene in bilateral testicular germ cell tumours in Japan. *Cancer Lett* **259**, 119-26 (2008).
57. Evans, R.A. et al. The congenital "magnesium-losing kidney". Report of two patients. *Q J Med* **50**, 39-52 (1981).
58. Boyadjiev, S.A. et al. A reciprocal translocation 46,XY,t(8;9)(p11.2;q13) in a bladder exstrophy patient disrupts CNTNAP3 and presents evidence of a pericentromeric duplication on chromosome 9. *Genomics* **85**, 622-9 (2005).
59. Vouk, K. et al. Combinations of genetic changes in the human cAMP-responsive element modulator gene: a clue towards understanding some forms of male infertility? *Mol Hum Reprod* **11**, 567-74 (2005).
60. Blendy, J.A., Kaestner, K.H., Weinbauer, G.F., Nieschlag, E. & Schutz, G. Severe impairment of spermatogenesis in mice lacking the CREM gene. *Nature* **380**, 162-5 (1996).
61. Palma, I. et al. Participation of OCT3/4 and beta-catenin during dysgenetic gonadal malignant transformation. *Cancer Lett* **263**, 204-11 (2008).
62. Kotula-Balak, M., Hejmej, A., Sadowska, J. & Bilinska, B. Connexin 43 expression in human and mouse testes with impaired spermatogenesis. *Eur J Histochem* **51**, 261-8 (2007).
63. Kim, C.J. et al. Severe combined adrenal and gonadal deficiency caused by novel mutations in the cholesterol side chain cleavage enzyme, P450scc. *J Clin Endocrinol Metab* **93**, 696-702 (2008).
64. Bhangoo, A., Wilson, R., New, M.I. & Ten, S. Donor splice mutation in the 11beta-hydroxylase (Cyp11B1) gene resulting in sex reversal: a case report and review of the literature. *J Pediatr Endocrinol Metab* **19**, 1267-82 (2006).
65. Kurabayashi, I. et al. Steroid 11-beta-hydroxylase deficiency caused by compound heterozygosity for a novel mutation, p.G314R, in one CYP11B1 allele, and a chimeric CYP11B2/CYP11B1 in the other allele. *Horm Res* **63**, 284-93 (2005).
66. Lee, H.H., Won, G.S., Chao, H.T., Lee, Y.J. & Chung, B.C. Novel missense mutations, GCC [Ala306]->GTC [Val] and ACG [Thr318]->CCG [Pro], in the CYP11B1 gene cause steroid 11beta-hydroxylase deficiency in the Chinese. *Clin Endocrinol (Oxf)* **62**, 418-22 (2005).
67. Kurabayashi, I. et al. A novel nonsense mutation in the Cyp11B1 gene from a subject with the steroid 11beta-hydroxylase form of congenital adrenal hyperplasia. *Endocr Res* **29**, 377-81 (2003).
68. Helmberg, A., Ausserer, B. & Kofler, R. Frame shift by insertion of 2 basepairs in codon 394 of CYP11B1 causes congenital adrenal hyperplasia due to steroid 11 beta-hydroxylase deficiency. *J Clin Endocrinol Metab* **75**, 1278-81 (1992).
69. Cingoz, S., Ozkan, B., Doneray, H. & Sakizli, M. Familial pericentric inversion chromosome 3 and R448C mutation of CYP11B1 gene in Turkish kindred with 11beta-hydroxylase deficiency. *J Endocrinol Invest* **30**, 285-91 (2007).

70. Yanase, T. et al. Combined 17 alpha-hydroxylase/17,20-lyase deficiency due to a 7-basepair duplication in the N-terminal region of the cytochrome P45017 alpha (CYP17) gene. *J Clin Endocrinol Metab* **70**, 1325-9 (1990).
71. Laflamme, N. et al. Mutation R96W in cytochrome P450c17 gene causes combined 17 alpha-hydroxylase/17-20-lyase deficiency in two French Canadian patients. *J Clin Endocrinol Metab* **81**, 264-8 (1996).
72. Benetti-Pinto, C.L., Vale, D., Garmes, H. & Bedone, A. 17-Hydroxyprogesterone deficiency as a cause of sexual infantilism and arterial hypertension: laboratory and molecular diagnosis--a case report. *Gynecol Endocrinol* **23**, 94-8 (2007).
73. Maffei, L. et al. Dysmetabolic syndrome in a man with a novel mutation of the aromatase gene: effects of testosterone, alendronate, and estradiol treatment. *J Clin Endocrinol Metab* **89**, 61-70 (2004).
74. Bobba, A., Marra, E., Lattanzio, P., Iolascon, A. & Giannattasio, S. Characterization of the CYP21 gene 5' flanking region in patients affected by 21-OH deficiency. *Hum Mutat* **15**, 481 (2000).
75. Stikkelbroeck, N.M. et al. High prevalence of testicular adrenal rest tumors, impaired spermatogenesis, and Leydig cell failure in adolescent and adult males with congenital adrenal hyperplasia. *J Clin Endocrinol Metab* **86**, 5721-8 (2001).
76. Ramazani, A., Kahrizi, K., Razaghiazar, M., Mahdиеh, N. & Koppens, P. The frequency of eight common point mutations in CYP21 gene in Iranian patients with congenital adrenal hyperplasia. *Iran Biomed J* **12**, 49-53 (2008).
77. Grigorescu Sido, A. et al. 21-Hydroxylase and 11beta-hydroxylase mutations in Romanian patients with classic congenital adrenal hyperplasia. *J Clin Endocrinol Metab* **90**, 5769-73 (2005).
78. Liao, X.Y., Zhang, Y.F. & Gu, X.F. [CYP21 gene point mutations study in 21-hydroxylase deficiency patients]. *Zhonghua Er Ke Za Zhi* **41**, 670-4 (2003).
79. Friaes, A. et al. CYP21A2 mutations in Portuguese patients with congenital adrenal hyperplasia: identification of two novel mutations and characterization of four different partial gene conversions. *Mol Genet Metab* **88**, 58-65 (2006).
80. Bojunga, J. et al. Structural and functional analysis of a novel mutation of CYP21B in a heterozygote carrier of 21-hydroxylase deficiency. *Hum Genet* **117**, 558-64 (2005).
81. Vakili, R. et al. Molecular analysis of the CYP21 gene and prenatal diagnosis in families with 21-hydroxylase deficiency in northeastern Iran. *Horm Res* **63**, 119-24 (2005).
82. Billerbeck, A.E. et al. Three novel mutations in CYP21 gene in Brazilian patients with the classical form of 21-hydroxylase deficiency due to a founder effect. *J Clin Endocrinol Metab* **87**, 4314-7 (2002).
83. Barbaro, M. et al. Functional analysis of two recurrent amino acid substitutions in the CYP21 gene from Italian patients with congenital adrenal hyperplasia. *J Clin Endocrinol Metab* **89**, 2402-7 (2004).
84. Nunez, B.S., Lobato, M.N., White, P.C. & Meseguer, A. Functional analysis of four CYP21 mutations from spanish patients with congenital adrenal hyperplasia. *Biochem Biophys Res Commun* **262**, 635-7 (1999).
85. Krone, N., Braun, A., Roscher, A.A. & Schwarz, H.P. A novel frameshift mutation (141delT) in exon 1 of the 21-hydroxylase gene (CYP21) in a patient

- with the salt wasting form of congenital adrenal hyperplasia. Mutation in brief no. 255. Online. *Hum Mutat* **14**, 90-1 (1999).
86. Kapelari, K. et al. A rapid screening for steroid 21-hydroxylase mutations in patients with congenital adrenal hyperplasia. Mutations in brief no. 247. Online. *Hum Mutat* **13**, 505 (1999).
 87. Parajes, S., Quinteiro, C., Dominguez, F. & Loidi, L. High frequency of copy number variations and sequence variants at CYP21A2 locus: implication for the genetic diagnosis of 21-hydroxylase deficiency. *PLoS ONE* **3**, e2138 (2008).
 88. Riepe, F.G. et al. Functional and structural consequences of a novel point mutation in the CYP21A2 gene causing congenital adrenal hyperplasia: potential relevance of helix C for P450 oxidoreductase-21-hydroxylase interaction. *J Clin Endocrinol Metab* **93**, 2891-5 (2008).
 89. Liivak, K., Tobi, S., Schlecht, H. & Tillmann, V. Incidence of classical 21-hydroxylase deficiency and distribution of CYP21A2 mutations in Estonia. *Horm Res* **69**, 227-32 (2008).
 90. Soardi, F.C. et al. Inhibition of CYP21A2 enzyme activity caused by novel missense mutations identified in Brazilian and Scandinavian patients. *J Clin Endocrinol Metab* **93**, 2416-20 (2008).
 91. Stikkelenbroeck, N.M. et al. CYP21 gene mutation analysis in 198 patients with 21-hydroxylase deficiency in The Netherlands: six novel mutations and a specific cluster of four mutations. *J Clin Endocrinol Metab* **88**, 3852-9 (2003).
 92. Menassa, R. et al. p.H62L, a rare mutation of the CYP21 gene identified in two forms of 21-hydroxylase deficiency. *J Clin Endocrinol Metab* **93**, 1901-8 (2008).
 93. Baradaran-Heravi, A. et al. Three novel CYP21A2 mutations and their protein modelling in patients with classical 21-hydroxylase deficiency from northeastern Iran. *Clin Endocrinol (Oxf)* **67**, 335-41 (2007).
 94. Krone, N. et al. Three novel point mutations of the CYP21 gene detected in classical forms of congenital adrenal hyperplasia due to 21-hydroxylase deficiency. *Exp Clin Endocrinol Diabetes* **114**, 111-7 (2006).
 95. Barbaro, M. et al. Functional studies of two novel and two rare mutations in the 21-hydroxylase gene. *J Mol Med* **84**, 521-8 (2006).
 96. Kharrat, M. et al. Molecular genetic analysis of Tunisian patients with a classic form of 21-hydroxylase deficiency: identification of four novel mutations and high prevalence of Q318X mutation. *J Clin Endocrinol Metab* **89**, 368-74 (2004).
 97. Usui, T. et al. Three novel mutations in Japanese patients with 21-hydroxylase deficiency. *Horm Res* **61**, 126-32 (2004).
 98. Zhang, H.J. et al. Variations in the promoter of CYP21A2 gene identified in a Chinese patient with simple virilizing form of 21-hydroxylase deficiency. *Clin Endocrinol (Oxf)* (2008).
 99. Araujo, R.S. et al. Microconversion between CYP21A2 and CYP21A1P promoter regions causes the nonclassical form of 21-hydroxylase deficiency. *J Clin Endocrinol Metab* **92**, 4028-34 (2007).
 100. Reijo, R., Alagappan, R.K., Patrizio, P. & Page, D.C. Severe oligozoospermia resulting from deletions of azoospermia factor gene on Y chromosome. *Lancet* **347**, 1290-3 (1996).
 101. Nuti, F. & Krausz, C. Gene polymorphisms/mutations relevant to abnormal spermatogenesis. *Reprod Biomed Online* **16**, 504-13 (2008).

102. Foresta, C., Ferlin, A. & Moro, E. Deletion and expression analysis of AZFa genes on the human Y chromosome revealed a major role for DBY in male infertility. *Hum Mol Genet* **9**, 1161-9 (2000).
103. A, Z. et al. Single nucleotide polymorphisms of the gonadotrophin-regulated testicular helicase (GRTH) gene may be associated with the human spermatogenesis impairment. *Hum Reprod* **21**, 755-9 (2006).
104. Tsai-Morris, C.H. et al. Polymorphism of the GRTH/DDX25 gene in normal and infertile Japanese men: a missense mutation associated with loss of GRTH phosphorylation. *Mol Hum Reprod* **13**, 887-92 (2007).
105. Guo, X. et al. Differential expression of VASA gene in ejaculated spermatozoa from normozoospermic men and patients with oligozoospermia. *Asian J Androl* **9**, 339-44 (2007).
106. Kempkensteffen, C. et al. The equilibrium of XIAP and Smac/DIABLO expression is gradually deranged during the development and progression of testicular germ cell tumours. *Int J Androl* **30**, 476-83 (2007).
107. Zuccarello, D. et al. A possible association of a human tektin-t gene mutation (A229V) with isolated non-syndromic asthenozoospermia: case report. *Hum Reprod* **23**, 996-1001 (2008).
108. Monk, M., Hitchins, M. & Hawes, S. Differential expression of the embryo/cancer gene ECSA(DPPA2), the cancer/testis gene BORIS and the pluripotency structural gene OCT4, in human preimplantation development. *Mol Hum Reprod* **14**, 347-55 (2008).
109. Brown, K.S., Cook, M., Hoess, K., Whitehead, A.S. & Mitchell, L.E. Evidence that the risk of spina bifida is influenced by genetic variation at the NOS3 locus. *Birth Defects Res A Clin Mol Teratol* **70**, 101-6 (2004).
110. Kido, T. & Lau, Y.F. The human Y-encoded testis-specific protein interacts functionally with eukaryotic translation elongation factor eEF1A, a putative oncoprotein. *Int J Cancer* **123**, 1573-85 (2008).
111. Garcia, N.M. et al. Deletion Mapping of Critical Region for Hypospadias, Penoscrotal Transposition and Imperforate Anus on Human Chromosome 13. *J Pediatr Urol* **2**, 233-242 (2006).
112. Wang, X. et al. Epidermal growth factor receptor protein expression and gene amplification in the chemorefractory metastatic embryonal carcinoma. *Mod Pathol* (2008).
113. Christensen, G.L. et al. Screening the SPO11 and EIF5A2 genes in a population of infertile men. *Fertil Steril* **84**, 758-60 (2005).
114. van der Linden, I.J., Heil, S.G., den Heijer, M. & Blom, H.J. The 894G>T variant in the endothelial nitric oxide synthase gene and spina bifida risk. *J Hum Genet* **52**, 516-20 (2007).
115. Guarducci, E. et al. Estrogen receptor alpha promoter polymorphism: stronger estrogen action is coupled with lower sperm count. *Hum Reprod* **21**, 994-1001 (2006).
116. Ji, G. et al. ERCC1 and ERCC2 polymorphisms and risk of idiopathic azoospermia in a Chinese population. *Reprod Biomed Online* **17**, 36-41 (2008).
117. Olshan, A.F., Shaw, G.M., Millikan, R.C., Laurent, C. & Finnell, R.H. Polymorphisms in DNA repair genes as risk factors for spina bifida and orofacial clefts. *Am J Med Genet A* **135**, 268-73 (2005).

118. Smith, E.P. et al. Estrogen resistance caused by a mutation in the estrogen-receptor gene in a man. *N Engl J Med* **331**, 1056-61 (1994).
119. Watanabe, M. et al. Haplotype analysis of the estrogen receptor 1 gene in male genital and reproductive abnormalities. *Hum Reprod* **22**, 1279-84 (2007).
120. Ban, S. et al. Genetic polymorphisms of ESR1 and ESR2 that may influence estrogen activity and the risk of hypospadias. *Hum Reprod* **23**, 1466-71 (2008).
121. Wang, Y. et al. Analysis of five single nucleotide polymorphisms in the ESR1 gene in cryptorchidism. *Birth Defects Res A Clin Mol Teratol* **82**, 482-5 (2008).
122. Galan, J.J. et al. Multilocus analyses of estrogen-related genes reveal involvement of the ESR1 gene in male infertility and the polygenic nature of the pathology. *Fertil Steril* **84**, 910-8 (2005).
123. Aschim, E.L. et al. The RsaI polymorphism in the estrogen receptor-beta gene is associated with male infertility. *J Clin Endocrinol Metab* **90**, 5343-8 (2005).
124. Beleza-Meireles, A., Kockum, I., Lundberg, F., Soderhall, C. & Nordenskjold, A. Risk factors for hypospadias in the estrogen receptor 2 gene. *J Clin Endocrinol Metab* **92**, 3712-8 (2007).
125. Wang, W. et al. [Association of FASL-844 polymorphism with the risk of idiopathic azoospermia and severe oligozoospermia]. *Zhonghua Nan Ke Xue* **13**, 302-5 (2007).
126. Pitteloud, N. et al. Mutations in fibroblast growth factor receptor 1 cause both Kallmann syndrome and normosmic idiopathic hypogonadotropic hypogonadism. *Proc Natl Acad Sci U S A* **103**, 6281-6 (2006).
127. Xu, N. et al. A mutation in the fibroblast growth factor receptor 1 gene causes fully penetrant normosmic isolated hypogonadotropic hypogonadism. *J Clin Endocrinol Metab* **92**, 1155-8 (2007).
128. Salenave, S. et al. Kallmann's syndrome: a comparison of the reproductive phenotypes in men carrying KAL1 and FGFR1/KAL2 mutations. *J Clin Endocrinol Metab* **93**, 758-63 (2008).
129. Beleza-Meireles, A. et al. FGFR2, FGF8, FGF10 and BMP7 as candidate genes for hypospadias. *Eur J Hum Genet* **15**, 405-10 (2007).
130. Zhang, W., Zhang, S., Xiao, C., Yang, Y. & Zhoucun, A. Mutation screening of the FKBP6 gene and its association study with spermatogenic impairment in idiopathic infertile men. *Reproduction* **133**, 511-6 (2007).
131. Miyamoto, T. et al. Is a genetic defect in Fkbp6 a common cause of azoospermia in humans? *Cell Mol Biol Lett* **11**, 557-69 (2006).
132. Kalfa, N. et al. Aberrant Expression of Ovary Determining Gene FOXL2 in the Testis and Juvenile Granulosa Cell Tumor in Children. *J Urol* (2008).
133. Gromoll, J., Simoni, M. & Nieschlag, E. An activating mutation of the follicle-stimulating hormone receptor autonomously sustains spermatogenesis in a hypophysectomized man. *J Clin Endocrinol Metab* **81**, 1367-70 (1996).
134. Phillip, M., Arbelle, J.E., Segev, Y. & Parvari, R. Male hypogonadism due to a mutation in the gene for the beta-subunit of follicle-stimulating hormone. *N Engl J Med* **338**, 1729-32 (1998).
135. Hu, Y. et al. Defective expression of Galphai2 in the testes of azoospermia patients and in the spermatozoa with low motility. *J Mol Med* **84**, 416-24 (2006).

136. Nakamoto, J.M. et al. Concurrent hormone resistance (pseudohypoparathyroidism type Ia) and hormone independence (testotoxicosis) caused by a unique mutation in the G alpha s gene. *Biochem Mol Med* **58**, 18-24 (1996).
137. Jorge, A.A., Souza, S.C., Arnhold, I.J. & Mendonca, B.B. The first homozygous mutation (S226I) in the highly-conserved WSXWS-like motif of the GH receptor causing Laron syndrome: suppression of GH secretion by GnRH analogue therapy not restored by dihydrotestosterone administration. *Clin Endocrinol (Oxf)* **60**, 36-40 (2004).
138. Layman, L.C. et al. Mutations in gonadotropin-releasing hormone receptor gene cause hypogonadotropic hypogonadism. *Nat Genet* **18**, 14-5 (1998).
139. Layman, L.C., Cohen, D.P., Xie, J. & Smith, G.D. Clinical phenotype and infertility treatment in a male with hypogonadotropic hypogonadism due to mutations Ala129Asp/Arg262Gln of the gonadotropin-releasing hormone receptor. *Fertil Steril* **78**, 1317-20 (2002).
140. Lin, L. et al. A homozygous R262Q mutation in the gonadotropin-releasing hormone receptor presenting as constitutional delay of growth and puberty with subsequent borderline oligospermia. *J Clin Endocrinol Metab* **91**, 5117-21 (2006).
141. Cai, Z.M. et al. Low expression of glycoprotein subunit 130 in ejaculated spermatozoa from asthenozoospermic men. *J Androl* **27**, 645-52 (2006).
142. de Roux, N. et al. Hypogonadotropic hypogonadism due to loss of function of the KiSS1-derived peptide receptor GPR54. *Proc Natl Acad Sci U S A* **100**, 10972-6 (2003).
143. Fragozo, M.C. et al. Activating mutation of the stimulatory G protein (gsp) as a putative cause of ovarian and testicular human stromal Leydig cell tumors. *J Clin Endocrinol Metab* **83**, 2074-8 (1998).
144. Paracchini, V. et al. GSTM1 [corrected] deletion modifies the levels of polycyclic aromatic hydrocarbon-DNA adducts in human sperm. *Mutat Res* **586**, 97-101 (2005).
145. Aydemir, B., Onaran, I., Kiziler, A.R., Alici, B. & Akyolcu, M.C. Increased oxidative damage of sperm and seminal plasma in men with idiopathic infertility is higher in patients with glutathione S-transferase Mu-1 null genotype. *Asian J Androl* **9**, 108-15 (2007).
146. Dhillon, V.S., Shahid, M. & Husain, S.A. Associations of MTHFR DNMT3b 4977 bp deletion in mtDNA and GSTM1 deletion, and aberrant CpG island hypermethylation of GSTM1 in non-obstructive infertility in Indian men. *Mol Hum Reprod* **13**, 213-22 (2007).
147. Wu, Q.F. et al. Genetic polymorphism of glutathione S-transferase T1 gene and susceptibility to idiopathic azoospermia or oligospermia in northwestern China. *Asian J Androl* **10**, 266-70 (2008).
148. Marques, C.J. et al. Abnormal methylation of imprinted genes in human sperm is associated with oligozoospermia. *Mol Hum Reprod* **14**, 67-74 (2008).
149. Ferguson, K.A., Chow, V. & Ma, S. Silencing of unpaired meiotic chromosomes and altered recombination patterns in an azoospermic carrier of a t(8;13) reciprocal translocation. *Hum Reprod* **23**, 988-95 (2008).
150. Lam, Y.H. & Tang, M.H. Risk of neural tube defects in the offspring of thalassaemia carriers in Hong Kong Chinese. *Prenat Diagn* **19**, 1135-7 (1999).

151. Li, D.Z., Liao, C. & Li, Q.M. Homozygous alpha-thalassemia associated with micropenis in a fetus. *Prenat Diagn* **26**, 180-1 (2006).
152. Jedrzejczak, P. et al. Quantitative assessment of transition proteins 1, 2 spermatid-specific linker histone H1-like protein transcripts in spermatozoa from normozoospermic and asthenozoospermic men. *Arch Androl* **53**, 199-205 (2007).
153. Franco, R. et al. Detection of high-mobility group proteins A1 and A2 represents a valid diagnostic marker in post-pubertal testicular germ cell tumours. *J Pathol* **214**, 58-64 (2008).
154. Murray, P.J. et al. Whole gene deletion of the hepatocyte nuclear factor-1beta gene in a patient with the prune-belly syndrome. *Nephrol Dial Transplant* **23**, 2412-5 (2008).
155. Edghill, E.L., Bingham, C., Ellard, S. & Hattersley, A.T. Mutations in hepatocyte nuclear factor-1beta and their related phenotypes. *J Med Genet* **43**, 84-90 (2006).
156. Mortlock, D.P. & Innis, J.W. Mutation of HOXA13 in hand-foot-genital syndrome. *Nat Genet* **15**, 179-80 (1997).
157. Utsch, B. et al. Molecular characterization of HOXA13 polyalanine expansion proteins in hand-foot-genital syndrome. *Am J Med Genet A* **143A**, 3161-8 (2007).
158. Goodman, F.R. et al. Novel HOXA13 mutations and the phenotypic spectrum of hand-foot-genital syndrome. *Am J Hum Genet* **67**, 197-202 (2000).
159. Tuzel, E. et al. Association of hypospadias with hypoplastic synpolydactyly and role of HOXD13 gene mutations. *Urology* **70**, 161-4 (2007).
160. Wang, Y. et al. Allelic variants in HOX genes in cryptorchidism. *Birth Defects Res A Clin Mol Teratol* **79**, 269-75 (2007).
161. Moisan, A.M. et al. New insight into the molecular basis of 3beta-hydroxysteroid dehydrogenase deficiency: identification of eight mutations in the HSD3B2 gene eleven patients from seven new families and comparison of the functional properties of twenty-five mutant enzymes. *J Clin Endocrinol Metab* **84**, 4410-25 (1999).
162. Vinci, G. et al. A deletion of a novel heat shock gene on the Y chromosome associated with azoospermia. *Mol Hum Reprod* **11**, 295-8 (2005).
163. Kleiman, S.E. et al. Histone H4 acetylation and AZFc involvement in germ cells of specimens of impaired spermatogenesis. *Fertil Steril* **89**, 1728-36 (2008).
164. Bentz, E.K. et al. A polymorphism of the interleukin-1 beta gene is associated with sperm pathology in humans. *Fertil Steril* **88**, 751-3 (2007).
165. Rozwadowska, N., Fiszer, D., Jedrzejczak, P., Kosicki, W. & Kurpisz, M. Interleukin-1 superfamily genes expression in normal or impaired human spermatogenesis. *Genes Immun* **8**, 100-7 (2007).
166. Marin, P. et al. Novel insulin-like 3 (INSL3) gene mutation associated with human cryptorchidism. *Am J Med Genet* **103**, 348-9 (2001).
167. El Houate, B. et al. Novel mutations involving the INSL3 gene associated with cryptorchidism. *J Urol* **177**, 1947-51 (2007).
168. Yamazawa, K. et al. Mutation and polymorphism analyses of INSL3 and LGR8/GREAT in 62 Japanese patients with cryptorchidism. *Horm Res* **67**, 73-6 (2007).
169. Ferlin, A. et al. Insulin-like factor 3 gene mutations in testicular dysgenesis syndrome: clinical and functional characterization. *Mol Hum Reprod* **12**, 401-6 (2006).

170. Volcik, K.A. et al. Evaluation of the jumonji gene and risk for spina bifida and congenital heart defects. *Am J Med Genet A* **126A**, 215-7 (2004).
171. Thepot, D. et al. Targeted disruption of the murine junD gene results in multiple defects in male reproductive function. *Development* **127**, 143-53 (2000).
172. Franco, B. et al. A gene deleted in Kallmann's syndrome shares homology with neural cell adhesion and axonal path-finding molecules. *Nature* **353**, 529-36 (1991).
173. Galan, J.J. et al. Association of genetic markers within the KIT and KITLG genes with human male infertility. *Hum Reprod* **21**, 3185-92 (2006).
174. Yatsenko, A.N. et al. Non-invasive genetic diagnosis of male infertility using spermatozoal RNA: KLHL10 mutations in oligozoospermic patients impair homodimerization. *Hum Mol Genet* **15**, 3411-9 (2006).
175. Serrano-Martin, M.M., Martinez-Aedo, M.J., Tartaglia, M. & Lopez-Siguero, J.P. [SOS1 mutation: a new cause of Noonan syndrome]. *An Pediatr (Barc)* **68**, 365-8 (2008).
176. McIntyre, A., Gilbert, D., Goddard, N., Looijenga, L. & Shipley, J. Genes, chromosomes and the development of testicular germ cell tumors of adolescents and adults. *Genes Chromosomes Cancer* **47**, 547-57 (2008).
177. Strobel, A., Issad, T., Camoin, L., Ozata, M. & Strosberg, A.D. A leptin missense mutation associated with hypogonadism and morbid obesity. *Nat Genet* **18**, 213-5 (1998).
178. Clement, K. et al. A mutation in the human leptin receptor gene causes obesity and pituitary dysfunction. *Nature* **392**, 398-401 (1998).
179. Simoni, M. et al. Polymorphisms of the luteinizing hormone/chorionic gonadotropin receptor gene: association with maldescended testes and male infertility. *Pharmacogenet Genomics* **18**, 193-200 (2008).
180. Kossack, N., Simoni, M., Richter-Unruh, A., Themmen, A.P. & Gromoll, J. Mutations in a novel, cryptic exon of the luteinizing hormone/chorionic gonadotropin receptor gene cause male pseudohermaphroditism. *PLoS Med* **5**, e88 (2008).
181. Bruysters, M. et al. A new LH receptor splice mutation responsible for male hypogonadism with subnormal sperm production in the propositus, and infertility with regular cycles in an affected sister. *Hum Reprod* **23**, 1917-23 (2008).
182. Kremer, H. et al. Male pseudohermaphroditism due to a homozygous missense mutation of the luteinizing hormone receptor gene. *Nat Genet* **9**, 160-4 (1995).
183. Rosenthal, S.M., Grumbach, M.M. & Kaplan, S.L. Gonadotropin-independent familial sexual precocity with premature Leydig and germinal cell maturation (familial testotoxicosis): effects of a potent luteinizing hormone-releasing factor agonist and medroxyprogesterone acetate therapy in four cases. *J Clin Endocrinol Metab* **57**, 571-9 (1983).
184. Gromoll, J., Eiholzer, U., Nieschlag, E. & Simoni, M. Male hypogonadism caused by homozygous deletion of exon 10 of the luteinizing hormone (LH) receptor: differential action of human chorionic gonadotropin and LH. *J Clin Endocrinol Metab* **85**, 2281-6 (2000).
185. Bhangoo, A.P. et al. Clinical case seminar: a novel LHX3 mutation presenting as combined pituitary hormonal deficiency. *J Clin Endocrinol Metab* **91**, 747-53 (2006).

186. Benoff, S. et al. Deletions in L-type calcium channel alpha1 subunit testicular transcripts correlate with testicular cadmium and apoptosis in infertile men with varicoceles. *Fertil Steril* **83**, 622-34 (2005).
187. Kalfa, N. et al. Mutations of CXorf6 are associated with a range of severities of hypospadias. *Eur J Endocrinol* (2008).
188. Fukami, M. et al. Mastermind-like domain-containing 1 (MAMLD1 or CXorf6) transactivates the Hes3 promoter, augments testosterone production, and contains the SF1 target sequence. *J Biol Chem* **283**, 5525-32 (2008).
189. Sato, H. et al. Polymorphic alleles of the human MEI1 gene are associated with human azoospermia by meiotic arrest. *J Hum Genet* **51**, 533-40 (2006).
190. Ebisch, I.M. et al. C677T methylenetetrahydrofolate reductase polymorphism interferes with the effects of folic acid and zinc sulfate on sperm concentration. *Fertil Steril* **80**, 1190-4 (2003).
191. Fontanella, B., Russolillo, G. & Meroni, G. MID1 mutations in patients with X-linked Opitz G/BBB syndrome. *Hum Mutat* **29**, 584-94 (2008).
192. Pan, H. et al. Increased (CTG/CAG)(n) lengths in myotonic dystrophy type 1 and Machado-Joseph disease genes in idiopathic azoospermia patients. *Hum Reprod* **17**, 1578-83 (2002).
193. Ferras, C., Zhou, X.L., Sousa, M., Lindblom, A. & Barros, A. DNA mismatch repair gene hMLH3 variants in meiotic arrest. *Fertil Steril* **88**, 1681-4 (2007).
194. Cretolle, C. et al. Currarino syndrome shown by prenatal onset ventriculomegaly and spinal dysraphism. *Am J Med Genet A* **143A**, 871-4 (2007).
195. Deng, Y. et al. Some single nucleotide polymorphisms of MSY2 gene might contribute to susceptibility to spermatogenic impairment in idiopathic infertile men. *Urology* **71**, 878-82 (2008).
196. Thangaraj, K., Joshi, M.B., Reddy, A.G., Rasalkar, A.A. & Singh, L. Sperm mitochondrial mutations as a cause of low sperm motility. *J Androl* **24**, 388-92 (2003).
197. Reynier, P. et al. Male infertility associated with multiple mitochondrial DNA rearrangements. *C R Acad Sci III* **320**, 629-36 (1997).
198. Kao, S., Chao, H.T. & Wei, Y.H. Mitochondrial deoxyribonucleic acid 4977-bp deletion is associated with diminished fertility and motility of human sperm. *Biol Reprod* **52**, 729-36 (1995).
199. Reutter, H., Betz, R.C., Ludwig, M. & Boemers, T.M. MTHFR 677 TT genotype in a mother and her child with Down syndrome, atrioventricular canal and exstrophy of the bladder: implications of a mutual genetic risk factor? *Eur J Pediatr* **165**, 566-8 (2006).
200. van der Put, N.M. et al. Mutated methylenetetrahydrofolate reductase as a risk factor for spina bifida. *Lancet* **346**, 1070-1 (1995).
201. van der Put, N.M. et al. Decreased methylene tetrahydrofolate reductase activity due to the 677C-->T mutation in families with spina bifida offspring. *J Mol Med* **74**, 691-4 (1996).
202. Ou, C.Y. et al. 5,10 Methylenetetrahydrofolate reductase genetic polymorphism as a risk factor for neural tube defects. *Am J Med Genet* **63**, 610-4 (1996).
203. van der Put, N.M., Eskes, T.K. & Blom, H.J. Is the common 677C-->T mutation in the methylenetetrahydrofolate reductase gene a risk factor for neural tube defects? A meta-analysis. *Qjm* **90**, 111-5 (1997).

204. Hol, F.A. et al. Molecular genetic analysis of the gene encoding the trifunctional enzyme MTHFD (methylenetetrahydrofolate-dehydrogenase, methenyltetrahydrofolate-cyclohydrolase, formyltetrahydrofolate synthetase) in patients with neural tube defects. *Clin Genet* **53**, 119-25 (1998).
205. Nijm, W.P. et al. Lack of evidence for sustained blood acetaldehyde concentrations during alcohol detoxification. *Res Commun Chem Pathol Pharmacol* **20**, 187-90 (1978).
206. de Franchis, R. et al. The C677T mutation of the 5,10-methylenetetrahydrofolate reductase gene is a moderate risk factor for spina bifida in Italy. *J Med Genet* **35**, 1009-13 (1998).
207. Johnson, W.G. et al. Distribution of alleles of the methylenetetrahydrofolate reductase (MTHFR) C677T gene polymorphism in familial spina bifida. *Am J Med Genet* **87**, 407-12 (1999).
208. Botto, L.D. & Yang, Q. 5,10-Methylenetetrahydrofolate reductase gene variants and congenital anomalies: a HuGE review. *Am J Epidemiol* **151**, 862-77 (2000).
209. Lucock, M., Daskalakis, I., Briggs, D., Yates, Z. & Levene, M. Altered folate metabolism and disposition in mothers affected by a spina bifida pregnancy: influence of 677c --> t methylenetetrahydrofolate reductase and 2756a --> g methionine synthase genotypes. *Mol Genet Metab* **70**, 27-44 (2000).
210. Volcik, K.A., Shaw, G.M., Lammer, E.J., Zhu, H. & Finnell, R.H. Evaluation of infant methylenetetrahydrofolate reductase genotype, maternal vitamin use, and risk of high versus low level spina bifida defects. *Birth Defects Res A Clin Mol Teratol* **67**, 154-7 (2003).
211. de Franchis, R. et al. Spina bifida and folate-related genes: a study of gene-gene interactions. *Genet Med* **4**, 126-30 (2002).
212. Volcik, K.A. et al. Methylenetetrahydrofolate reductase and spina bifida: evaluation of level of defect and maternal genotypic risk in Hispanics. *Am J Med Genet* **95**, 21-7 (2000).
213. Pietrzyk, J.J., Bik-Multanowski, M., Sanak, M. & Twardowska, M. Polymorphisms of the 5,10-methylenetetrahydrofolate and the methionine synthase reductase genes as independent risk factors for spina bifida. *J Appl Genet* **44**, 111-3 (2003).
214. Christensen, B. et al. Genetic polymorphisms in methylenetetrahydrofolate reductase and methionine synthase, folate levels in red blood cells, and risk of neural tube defects. *Am J Med Genet* **84**, 151-7 (1999).
215. Kirke, P.N. et al. Impact of the MTHFR C677T polymorphism on risk of neural tube defects: case-control study. *Bmj* **328**, 1535-6 (2004).
216. Lee, H.C. et al. Association study of four polymorphisms in three folate-related enzyme genes with non-obstructive male infertility. *Hum Reprod* **21**, 3162-70 (2006).
217. Nie, D., Yang, X. & Yankai, Z. Molecular cloning and expression profile analysis of a novel mouse testis-specific expression gene mtIQ1. *Mol Biol Rep* (2008).
218. Selvi Rani, D. et al. A novel missense mutation C11994T in the mitochondrial ND4 gene as a cause of low sperm motility in the Indian subcontinent. *Fertil Steril* **86**, 1783-5 (2006).

219. Gueant-Rodriguez, R.M. et al. Transcobalamin and methionine synthase reductase mutated polymorphisms aggravate the risk of neural tube defects in humans. *Neurosci Lett* **344**, 189-92 (2003).
220. Doolin, M.T. et al. Maternal genetic effects, exerted by genes involved in homocysteine remethylation, influence the risk of spina bifida. *Am J Hum Genet* **71**, 1222-6 (2002).
221. Zhu, H. et al. Homocysteine remethylation enzyme polymorphisms and increased risks for neural tube defects. *Mol Genet Metab* **78**, 216-21 (2003).
222. Nye, J.S. et al. Myelocystocele-cloacal exstrophy in a pedigree with a mitochondrial 12S rRNA mutation, aminoglycoside-induced deafness, pigmentary disturbances, and spinal anomalies. *Teratology* **61**, 165-71 (2000).
223. van der Linden, I.J. et al. The methionine synthase reductase 66A>G polymorphism is a maternal risk factor for spina bifida. *J Mol Med* **84**, 1047-54 (2006).
224. Wilson, A. et al. A common variant in methionine synthase reductase combined with low cobalamin (vitamin B12) increases risk for spina bifida. *Mol Genet Metab* **67**, 317-23 (1999).
225. Westerveld, G.H. et al. Mutations in the testis-specific NALP14 gene in men suffering from spermatogenic failure. *Hum Reprod* **21**, 3178-84 (2006).
226. Looijenga, L.H., Gillis, A.J., Stoop, H.J., Hersmus, R. & Oosterhuis, J.W. Chromosomes and expression in human testicular germ-cell tumors: insight into their cell of origin and pathogenesis. *Ann NY Acad Sci* **1120**, 187-214 (2007).
227. Jensen, L.E., Hoess, K., Whitehead, A.S. & Mitchell, L.E. The NAT1 C1095A polymorphism, maternal multivitamin use and smoking, and the risk of spina bifida. *Birth Defects Res A Clin Mol Teratol* **73**, 512-6 (2005).
228. Deak, K.L. et al. SNPs in the neural cell adhesion molecule 1 gene (NCAM1) may be associated with human neural tube defects. *Hum Genet* **117**, 133-42 (2005).
229. Barbaro, M. et al. Isolated 46,XY gonadal dysgenesis in two sisters caused by a Xp21.2 interstitial duplication containing the DAX1 gene. *J Clin Endocrinol Metab* **92**, 3305-13 (2007).
230. Smyk, M. et al. Male-to-female sex reversal associated with an approximately 250 kb deletion upstream of NR0B1 (DAX1). *Hum Genet* **122**, 63-70 (2007).
231. Wada, Y., Okada, M., Fukami, M., Sasagawa, I. & Ogata, T. Association of cryptorchidism with Gly146Ala polymorphism in the gene for steroidogenic factor-1. *Fertil Steril* **85**, 787-90 (2006).
232. Philibert, P. et al. Mutational analysis of steroidogenic factor 1 (NR5a1) in 24 boys with bilateral anorchia: a French collaborative study. *Hum Reprod* **22**, 3255-61 (2007).
233. Kohler, B. et al. Five novel mutations in steroidogenic factor 1 (SF1, NR5A1) in 46,XY patients with severe underandrogenization but without adrenal insufficiency. *Hum Mutat* **29**, 59-64 (2008).
234. Lin, L. et al. Heterozygous missense mutations in steroidogenic factor 1 (SF1/Ad4BP, NR5A1) are associated with 46,XY disorders of sex development with normal adrenal function. *J Clin Endocrinol Metab* **92**, 991-9 (2007).
235. Reuter, A.L., Goji, K., Bingham, N.C., Matsuo, M. & Parker, K.L. A novel mutation in the accessory DNA-binding domain of human steroidogenic factor 1

- causes XY gonadal dysgenesis without adrenal insufficiency. *Eur J Endocrinol* **157**, 233-8 (2007).
236. Coutant, R. et al. Heterozygous mutation of steroidogenic factor-1 in 46,XY subjects may mimic partial androgen insensitivity syndrome. *J Clin Endocrinol Metab* **92**, 2868-73 (2007).
237. Achermann, J.C., Ito, M., Ito, M., Hindmarsh, P.C. & Jameson, J.L. A mutation in the gene encoding steroidogenic factor-1 causes XY sex reversal and adrenal failure in humans. *Nat Genet* **22**, 125-6 (1999).
238. Kojima, Y. et al. Role of transcription factors Ad4bp/SF-1 and DAX-1 in steroidogenesis and spermatogenesis in human testicular development and idiopathic azoospermia. *Int J Urol* **13**, 785-93 (2006).
239. Bardoni, B. et al. A dosage sensitive locus at chromosome Xp21 is involved in male to female sex reversal. *Nat Genet* **7**, 497-501 (1994).
240. Yu, R.N., Achermann, J.C., Ito, M. & Jameson, J.L. The Role of DAX-1 in Reproduction. *Trends Endocrinol Metab* **9**, 169-75 (1998).
241. Hammoud, S., Emery, B.R., Aoki, V.W. & Carrell, D.T. Identification of genetic variation in the 5' and 3' non-coding regions of the protamine genes in patients with protamine deregulation. *Arch Androl* **53**, 267-74 (2007).
242. Christensen, G.L. et al. Identification of polymorphisms and balancing selection in the male infertility candidate gene, ornithine decarboxylase antizyme 3. *BMC Med Genet* **7**, 27 (2006).
243. Kim ST, P.N., Yi LS, Gye MC. Expression of p57kip2 in germ cells and Leydig cells in human testis. . *Arch Androl.* **52(6)**, 463-9 (2006).
244. Fedele, M. et al. PATZ1 gene has a critical role in the spermatogenesis and testicular tumours. *J Pathol* **215**, 39-47 (2008).
245. Lu, W. et al. Screening for novel PAX3 polymorphisms and risks of spina bifida. *Birth Defects Res A Clin Mol Teratol* **79**, 45-9 (2007).
246. Hol, F.A. et al. A frameshift mutation in the gene for PAX3 in a girl with spina bifida and mild signs of Waardenburg syndrome. *J Med Genet* **32**, 52-6 (1995).
247. Enaw, J.O. et al. CHKA and PCYT1A gene polymorphisms, choline intake and spina bifida risk in a California population. *BMC Med* **4**, 36 (2006).
248. Zhu, H. et al. Promoter haplotype combinations for the human PDGFRA gene are associated with risk of neural tube defects. *Mol Genet Metab* **81**, 127-32 (2004).
249. Joosten, P.H., Toepoel, M., Mariman, E.C. & Van Zoelen, E.J. Promoter haplotype combinations of the platelet-derived growth factor alpha-receptor gene predispose to human neural tube defects. *Nat Genet* **27**, 215-7 (2001).
250. Zhang, J. et al. ERp57 is a potential biomarker for human fertilization capability. *Mol Hum Reprod* **13**, 633-9 (2007).
251. Zhang, J. et al. Phosphatidylethanolamine N-methyltransferase (PEMT) gene polymorphisms and risk of spina bifida. *Am J Med Genet A* **140**, 785-9 (2006).
252. Maiorino, M. et al. Genetic variations of gpx-4 and male infertility in humans. *Biol Reprod* **68**, 1134-41 (2003).
253. Weiss, J. et al. Hypogonadism caused by a single amino acid substitution in the beta subunit of luteinizing hormone. *N Engl J Med* **326**, 179-83 (1992).
254. Hershkovitz, E. et al. Homozygous mutation G539R in the gene for P450 oxidoreductase in a family previously diagnosed as having 17,20 lyase deficiency. *J Clin Endocrinol Metab* (2008).

255. Cheng, C.J. et al. Aberrant expression and distribution of the OCT-4 transcription factor in seminomas. *J Biomed Sci* **14**, 797-807 (2007).
256. Burton, K.A. et al. Haploinsufficiency at the Protein Kinase A RI{alpha} Gene Locus Leads to Fertility Defects in Male Mice and Men. *Mol Endocrinol* **20**, 2504-2513 (2006).
257. Ravel, C. et al. Mutations in the protamine 1 gene associated with male infertility. *Mol Hum Reprod* **13**, 461-4 (2007).
258. Sinisi, A.A. et al. Homozygous mutation in the prokineticin-receptor2 gene (Val274Asp) presenting as reversible Kallmann syndrome and persistent oligozoospermia: Case Report. *Hum Reprod* (2008).
259. Fofanova, O. et al. Compound heterozygous deletion of the PROP-1 gene in children with combined pituitary hormone deficiency. *J Clin Endocrinol Metab* **83**, 2601-4 (1998).
260. Chakrabarti, R., Cheng, L., Puri, P., Soler, D. & Vijayaraghavan, S. Protein phosphatase PP1 gamma 2 in sperm morphogenesis and epididymal initiation of sperm motility. *Asian J Androl* **9**, 445-52 (2007).
261. Carrell, D.T. Elucidating the genetics of male infertility: understanding transcriptional and translational regulatory networks involved in spermatogenesis. *Int J Androl* (2008).
262. Sarkozy, A., Digilio, M.C. & Dallapiccola, B. Leopard syndrome. *Orphanet J Rare Dis* **3**, 13 (2008).
263. Cassidy, S.B. & Schwartz, S. Prader-Willi and Angelman syndromes. Disorders of genomic imprinting. *Medicine (Baltimore)* **77**, 140-51 (1998).
264. Tsujimura, A. et al. Associations of homologous RNA-binding motif gene on the X chromosome (RBMX) and its like sequence on chromosome 9 (RBMLX9) with non-obstructive azoospermia. *Asian J Androl* **8**, 213-8 (2006).
265. Westerveld, G.H. et al. Heterogeneous nuclear ribonucleoprotein G-T (HNRNP G-T) mutations in men with impaired spermatogenesis. *Mol Hum Reprod* **10**, 265-9 (2004).
266. Ferlin, A., Moro, E., Garolla, A. & Foresta, C. Human male infertility and Y chromosome deletions: role of the AZF-candidate genes DAZ, RBM and DFFRY. *Hum Reprod* **14**, 1710-6 (1999).
267. Mauro, V. et al. Reg I protein in healthy and seminoma human testis. *Histol Histopathol* **23**, 1195-203 (2008).
268. Shaw, G.M. et al. Maternal periconceptional vitamin use, genetic variation of infant reduced folate carrier (A80G), and risk of spina bifida. *Am J Med Genet* **108**, 1-6 (2002).
269. Tomaselli, S. et al. Syndromic true hermaphroditism due to an R-spondin1 (RSPO1) homozygous mutation. *Hum Mutat* **29**, 220-6 (2008).
270. Gorlov, I.P. et al. Mutations of the GREAT gene cause cryptorchidism. *Hum Mol Genet* **11**, 2309-18 (2002).
271. Bogatcheva, N.V. et al. T222P mutation of the insulin-like 3 hormone receptor LGR8 is associated with testicular maldescent and hinders receptor expression on the cell surface membrane. *Am J Physiol Endocrinol Metab* **292**, E138-44 (2007).
272. Capkova, J., Elzeinova, F. & Novak, P. Increased expression of secretory actin-binding protein on human spermatozoa is associated with poor semen quality. *Hum Reprod* **22**, 1396-404 (2007).

273. Salerno, A., Kohlhase, J. & Kaplan, B.S. Townes-Brocks syndrome and renal dysplasia: a novel mutation in the SALL1 gene. *Pediatr Nephrol* **14**, 25-8 (2000).
274. Bonache, S., Martinez, J., Fernandez, M., Bassas, L. & Larriba, S. Single nucleotide polymorphisms in succinate dehydrogenase subunits and citrate synthase genes: association results for impaired spermatogenesis. *Int J Androl* **30**, 144-52 (2007).
275. Lazaros, L. et al. Evidence for association of sex hormone-binding globulin and androgen receptor genes with semen quality. *Andrologia* **40**, 186-91 (2008).
276. Faivre, L. et al. Deletion of the SIM1 gene (6q16.2) in a patient with a Prader-Willi-like phenotype. *J Med Genet* **39**, 594-6 (2002).
277. de Jong, J. et al. Differential expression of SOX17 and SOX2 in germ cells and stem cells has biological and clinical implications. *J Pathol* **215**, 21-30 (2008).
278. Williamson, K.A. et al. Mutations in SOX2 cause anophthalmia-esophageal-genital (AEG) syndrome. *Hum Mol Genet* **15**, 1413-22 (2006).
279. Wagner, T. et al. Autosomal sex reversal and campomelic dysplasia are caused by mutations in and around the SRY-related gene SOX9. *Cell* **79**, 1111-20 (1994).
280. Thomas, K. et al. SP1 transcription factors in male germ cell development and differentiation. *Mol Cell Endocrinol* **270**, 1-7 (2007).
281. Zhang, Z. et al. A heterozygous mutation disrupting the SPAG16 gene results in biochemical instability of central apparatus components of the human sperm axoneme. *Biol Reprod* **77**, 864-71 (2007).
282. Dan, L., Lifang, Y. & Guangxiu, L. Expression and possible functions of a novel gene SPATA12 in human testis. *J Androl* **28**, 502-12 (2007).
283. Xu, M. et al. Identification and characterization of a novel human testis-specific Golgi protein, NYD-SP12. *Mol Hum Reprod* **9**, 9-17 (2003).
284. Dam, A.H. et al. Homozygous mutation in SPATA16 is associated with male infertility in human globozoospermia. *Am J Hum Genet* **81**, 813-20 (2007).
285. Vilchis, F. et al. Novel compound heterozygous mutations in the SRD5A2 gene from 46,XY infants with ambiguous external genitalia. *J Hum Genet* **53**, 401-6 (2008).
286. Jager, R.J., Anvret, M., Hall, K. & Scherer, G. A human XY female with a frame shift mutation in the candidate testis-determining gene SRY. *Nature* **348**, 452-4 (1990).
287. Paris, F. et al. Primary amenorrhea in a 46,XY adolescent girl with partial gonadal dysgenesis: identification of a new SRY gene mutation. *Fertil Steril* **88**, 1437 e21-5 (2007).
288. Salehi, L.B. et al. Identification of a novel mutation in the SRY gene in a 46, XY female patient. *Eur J Med Genet* **49**, 494-8 (2006).
289. Gimelli, G. et al. Identification and molecular modelling of a novel familial mutation in the SRY gene implicated in the pure gonadal dysgenesis. *Eur J Hum Genet* **15**, 76-80 (2007).
290. Zhou, C., Fu, J.J., Li, L.Y. & Lu, G.X. Two novel mutations in SRY gene form Chinese sex reversal XY females. *Yi Chuan Xue Bao* **32**, 443-9 (2005).
291. Assumpcao, J.G. et al. A naturally occurring deletion in the SRY promoter region affecting the Sp1 binding site is associated with sex reversal. *J Endocrinol Invest* **28**, 651-6 (2005).

292. Nakae, J. et al. Analysis of the steroidogenic acute regulatory protein (StAR) gene in Japanese patients with congenital lipoid adrenal hyperplasia. *Hum Mol Genet* **6**, 571-6 (1997).
293. Miyamoto, T. et al. Azoospermia in patients heterozygous for a mutation in SYCP3. *Lancet* **362**, 1714-9 (2003).
294. Ruiz-Pesini, E. et al. Human mtDNA haplogroups associated with high or reduced spermatozoa motility. *Am J Hum Genet* **67**, 682-96 (2000).
295. Akinloye, O., Gromoll, J., Callies, C., Nieschlag, E. & Simoni, M. Mutation analysis of the X-chromosome linked, testis-specific TAF7L gene in spermatogenic failure. *Andrologia* **39**, 190-5 (2007).
296. Sasaki, G. et al. Novel mutation of TBX3 in a Japanese family with ulnar-mammary syndrome: implication for impaired sex development. *Am J Med Genet* **110**, 365-9 (2002).
297. Pietrzyk, J.J. & Bik-Multanowski, M. 776C>G polymorphism of the transcobalamin II gene as a risk factor for spina bifida. *Mol Genet Metab* **80**, 364 (2003).
298. Jensen, L.E. et al. The human T locus and spina bifida risk. *Hum Genet* **115**, 475-82 (2004).
299. Morrison, K. et al. Genetic mapping of the human homologue (T) of mouse T(Brachyury) and a search for allele association between human T and spina bifida. *Hum Mol Genet* **5**, 669-74 (1996).
300. Aarabi, M., Ousati-Ashtiani, Z., Nazarian, A., Modarressi, M.H. & Heidari, M. Association of TGIFLX/Y mRNA expression with azoospermia in infertile men. *Mol Reprod Dev* (2008).
301. Jagiello, P. et al. A novel splice site mutation in the TRIM37 gene causes mulibrey nanism in a Turkish family with phenotypic heterogeneity. *Hum Mutat* **21**, 630-5 (2003).
302. Vodicka, R. et al. TSPY gene copy number as a potential new risk factor for male infertility. *Reprod Biomed Online* **14**, 579-87 (2007).
303. Li, Y. et al. The Y-encoded TSPY protein: a significant marker potentially plays a role in the pathogenesis of testicular germ cell tumors. *Hum Pathol* **38**, 1470-81 (2007).
304. Su, D. et al. Mutation screening and association study of the TSSK4 Gene in Chinese infertile men with impaired spermatogenesis. *J Androl* **29**, 374-8 (2008).
305. Duriez, B. et al. A common variant in combination with a nonsense mutation in a member of the thioredoxin family causes primary ciliary dyskinesia. *Proc Natl Acad Sci U S A* **104**, 3336-41 (2007).
306. Suryavathi, V. et al. Novel variants in UBE2B gene and idiopathic male infertility. *J Androl* **29**, 564-71 (2008).
307. Huang, I. et al. Novel UBE2B-associated polymorphisms in an azoospermic/oligozoospermic population. *Asian J Androl* **10**, 461-6 (2008).
308. Volcik, K.A., Shaw, G.M., Zhu, H., Lammer, E.J. & Finnell, R.H. Risk factors for neural tube defects: associations between uncoupling protein 2 polymorphisms and spina bifida. *Birth Defects Res A Clin Mol Teratol* **67**, 158-61 (2003).
309. Jones, M.H. et al. The Drosophila developmental gene fat facets has a human homologue in Xp11.4 which escapes X-inactivation and has related sequences on Yq11.2. *Hum Mol Genet* **5**, 1695-701 (1996).

310. Sun, C. et al. An azoospermic man with a de novo point mutation in the Y-chromosomal gene USP9Y. *Nat Genet* **23**, 429-32 (1999).
311. Kuo, P.L. et al. Expression profiles of the DAZ gene family in human testis with and without spermatogenic failure. *Fertil Steril* **81**, 1034-40 (2004).
312. Zhang, J. et al. Novel mutations in ubiquitin-specific protease 26 gene might cause spermatogenesis impairment and male infertility. *Asian J Androl* **9**, 809-14 (2007).
313. Rohozinski, J., Lamb, D.J. & Bishop, C.E. UTP14c is a recently acquired retrogene associated with spermatogenesis and fertility in man. *Biol Reprod* **74**, 644-51 (2006).
314. Kibar, Z. et al. Mutations in VANGL1 associated with neural-tube defects. *N Engl J Med* **356**, 1432-7 (2007).
315. Gao, F. et al. The Wilms tumor gene, Wt1, is required for Sox9 expression and maintenance of tubular architecture in the developing testis. *Proc Natl Acad Sci U S A* **103**, 11987-92 (2006).
316. Schumacher, V. et al. Characteristics of testicular dysgenesis syndrome and decreased expression of SRY and SOX9 in Frasier syndrome. *Mol Reprod Dev* **75**, 1484-94 (2008).
317. Barbaux, S. et al. Donor splice-site mutations in WT1 are responsible for Frasier syndrome. *Nat Genet* **17**, 467-70 (1997).
318. Hastie, N.D. Dominant negative mutations in the Wilms tumour (WT1) gene cause Denys-Drash syndrome--proof that a tumour-suppressor gene plays a crucial role in normal genitourinary development. *Hum Mol Genet* **1**, 293-5 (1992).
319. Liang, J. et al. XPC gene polymorphisms and risk of idiopathic azoospermia or oligozoospermia in a Chinese population. *Int J Androl* (2007).
320. Gu, A. et al. DNA repair gene XRCC1 and XPD polymorphisms and the risk of idiopathic azoospermia in a Chinese population. *Int J Mol Med* **20**, 743-7 (2007).
321. Hammoud, S., Emery, B.R., Dunn, D., Weiss, R.B. & Carrell, D.T. Sequence alterations in the YBX2 gene are associated with male factor infertility. *Fertil Steril* (2008).
322. Gianotten, J. et al. Chromosomal region 11p15 is associated with male factor subfertility. *Mol Hum Reprod* **9**, 587-92 (2003).
323. Yoshida, A. et al. Dicentric Y chromosome in an azoospermic male. *Mol Hum Reprod* **3**, 709-12 (1997).
324. Perrin, A. et al. Meiotic segregation in spermatozoa of a 45,XY,-14,der(18)t(14;18)(q11;p11.3) translocation carrier: a case report. *Hum Reprod* **22**, 729-32 (2007).
325. Papenhausen, P.R., Mueller, O.T., Bercu, B., Salazar, J. & Tedesco, T.A. Cell line segregation in a 45,X/46,XY mosaic child with asymmetric leg growth. *Clin Genet* **40**, 237-41 (1991).
326. Collodel, G., Cosci, I., Pascarelli, A.N. & Moretti, E. Sperm ultrastructure and 18,X, Y aneuploidies in a man with a 46 XY, 47 XY + 18 mosaic karyotype: case report. *J Assist Reprod Genet* **24**, 373-6 (2007).
327. Coco, R., Rahn, M.I., Estanga, P.G., Antonioli, G. & Solari, A.J. A constitutional complex chromosome rearrangement involving meiotic arrest in an azoospermic male: case report. *Hum Reprod* **19**, 2784-90 (2004).

328. Gabriel-Robez, O., Ratomponirina, C., Dutrillaux, B., Carre-Pigeon, F. & Rumpler, Y. Meiotic association between the XY chromosomes and the autosomal quadrivalent of a reciprocal translocation in two infertile men, 46,XY,t(19;22) and 46,XY,t(17;21). *Cytogenet Cell Genet* **43**, 154-60 (1986).
329. Paoloni-Giacobino, A. et al. Familial t(6;21)(p21.1;p13) translocation associated with male-only sterility. *Clin Genet* **58**, 324-8 (2000).
330. Black, L.D., Nudell, D.M., Cha, I., Cherry, A.M. & Turek, P.J. Compound genetic factors as a cause of male infertility: case report. *Hum Reprod* **15**, 449-51 (2000).
331. Pinho, M.J. et al. Unique t(Y;1)(q12;q12) reciprocal translocation with loss of the heterochromatic region of chromosome 1 in a male with azoospermia due to meiotic arrest: a case report. *Hum Reprod* **20**, 689-96 (2005).
332. Ma, S. et al. ICSI and the transmission of X-autosomal translocation: a three-generation evaluation of X;20 translocation: case report. *Hum Reprod* **18**, 1377-82 (2003).
333. Lu, P.Y., Hammitt, D.G., Zinsmeister, A.R. & Dewald, G.W. Dual color fluorescence in situ hybridization to investigate aneuploidy in sperm from 33 normal males and a man with a t(2;4;8)(q23;q27;p21). *Fertil Steril* **62**, 394-9 (1994).
334. Dauwerse, J.G. et al. A t(4;6)(q12;p23) translocation disrupts a membrane-associated O-acetyl transferase gene (MBOAT1) in a patient with a novel brachydactyly-syndactyly syndrome. *Eur J Hum Genet* **15**, 743-51 (2007).
335. Ravel, C. et al. Tail stump syndrome associated with chromosomal translocation in two brothers attempting intracytoplasmic sperm injection. *Fertil Steril* **86**, 719 e1-7 (2006).
336. Mikelsaar, R., Pauklin, M., Lissitsina, J. & Punab, M. Reciprocal translocation t(7;16)(q21.2;p13.3) in an infertile man. *Fertil Steril* **86**, 719 e9-11 (2006).
337. Leonard, C., Bisson, J.P. & David, G. Male sterility associated with familial translocation heterozygosity: t(8;15) (q22;p11). *Arch Androl* **2**, 269-75 (1979).
338. Baccetti, B. et al. 10, 15 reciprocal translocation in an infertile man: ultrastructural and fluorescence in-situ hybridization sperm study: case report. *Hum Reprod* **18**, 2302-8 (2003).
339. Geneix, A. et al. Sperm analysis by FISH in a case of t(17; 22) (q11; q12) balanced translocation: case report. *Hum Reprod* **17**, 325-31 (2002).
340. Cantu, J.M. et al. Azoospermia and duplication 3qter as distinct consequences of a familial t(X;3) (q26;q13.2). *Am J Med Genet* **20**, 677-84 (1985).
341. Perrin, A. et al. Segregation of chromosomes in sperm of a t(X;18)(q11;p11.1) carrier inherited from his mother: case report. *Hum Reprod* **23**, 227-30 (2008).
342. Gillem Lanuza, F., Vargas Torcal, F., Amelin Chauve, M.C. & Gabarra Lamas, J. [Complete triploidy in a live newborn infant. Review and contribution of a new case]. *An Esp Pediatr* **29**, 143-8 (1988).
343. Bouters, R., Vandeplassche, M. & De Moor, A. An intersex (male pseudohermaphrodite) horse with 64XX/XXY mosaicism. *J Reprod Fertil Suppl*, 375-6 (1975).
344. Takano, T. et al. Interstitial deletion of chromosome 1q [del(1)(q24q25.3)] identified by fluorescence in situ hybridization and gene dosage analysis of

- apolipoprotein A-II, coagulation factor V, and antithrombin III. *Am J Med Genet* **68**, 207-10 (1997).
345. Scarbrough, P.R. et al. Interstitial deletion of chromosome 1 [del(1)(q25q32)] in an infant with prune belly sequence. *Prenat Diagn* **8**, 169-74 (1988).
346. Reutter, H. et al. Genome-wide analysis for micro-aberrations in familial exstrophy of the bladder using array-based comparative genomic hybridization. *BJU Int* **100**, 646-50 (2007).
347. Weber, S. et al. Gene locus ambiguity in posterior urethral valves/prune-belly syndrome. *Pediatr Nephrol* **20**, 1036-42 (2005).
348. Nye, J.S. et al. Myelomeningocele and Waardenburg syndrome (type 3) in patients with interstitial deletions of 2q35 and the PAX3 gene: possible digenic inheritance of a neural tube defect. *Am J Med Genet* **75**, 401-8 (1998).
349. Melnyk, A.R. & Muraskas, J. Interstitial deletion of chromosome 2 region in a malformed infant. *Am J Med Genet* **45**, 49-51 (1993).
350. Shim, S.H., Wyandt, H.E., McDonald-McGinn, D.M., Zackai, E.Z. & Milunsky, A. Molecular cytogenetic characterization of multiple intrachromosomal rearrangements of chromosome 2q in a patient with Waardenburg's syndrome and other congenital defects. *Clin Genet* **66**, 46-52 (2004).
351. Seller, M.J., Mazzaschi, R., Ogilvie, C.M. & Mohammed, S. A trisomy 2 fetus with severe neural tube defects and other abnormalities. *Clin Dysmorphol* **13**, 25-7 (2004).
352. Cassidy, S.B., Heller, R.M., Chazen, E.M. & Engel, E. The chromosome 2 distal short arm trisomy syndrome. *J Pediatr* **91**, 934-8 (1977).
353. McIntyre, A. et al. Genomic copy number and expression patterns in testicular germ cell tumours. *Br J Cancer* **97**, 1707-12 (2007).
354. Simovich, M.J. et al. Delineation of the proximal 3q microdeletion syndrome. *Am J Med Genet A* **146A**, 1729-35 (2008).
355. Kennedy, D. et al. Inverted duplication of the distal short arm of chromosome 3 associated with lobar holoprosencephaly and lumbosacral meningomyelocele. *Am J Med Genet* **91**, 167-70 (2000).
356. de Azevedo Moreira, L.M. et al. Multiple congenital malformations including severe eye anomalies and abnormal cerebellar development with Dandy-Walker malformation in a girl with partial trisomy 3q. *Ophthalmic Genet* **26**, 37-43 (2005).
357. Ounap, K., Ilus, T. & Bartsch, O. A girl with inverted triplication of chromosome 3q25.3 --> q29 and multiple congenital anomalies consistent with 3q duplication syndrome. *Am J Med Genet A* **134**, 434-8 (2005).
358. Kosaki, R. et al. OEIS complex with del(3)(q12.2q13.2). *Am J Med Genet A* **135**, 224-6 (2005).
359. So, J. et al. Diagnosis of a terminal deletion of 4p with duplication of Xp22.31 in a patient with findings of Opitz G/BBB syndrome and Wolf-Hirschhorn syndrome. *Am J Med Genet A* **146A**, 103-9 (2008).
360. Kitsiou-Tzeli, S. et al. Distal del(4) (q33) syndrome: detailed clinical presentation and molecular description with array-CGH. *Eur J Med Genet* **51**, 61-7 (2008).
361. Senses, D.A. et al. Partial trisomy 4(q31qter) due to maternal 4;5 balanced translocation in a neonate. *Genet Couns* **18**, 163-70 (2007).

362. Mowat, D., Jauch, A., Robson, L. & Smith, A. Duplication within chromosome 5q characterized by fluorescence in situ hybridization. *Am J Med Genet* **83**, 361-4 (1999).
363. Rossi, E. et al. 8.5 Mb deletion at distal 5p in a male ascertained for azoospermia. *Am J Med Genet A* **133A**, 189-92 (2005).
364. Tanteles, G.A., Yates, K., Martin, K. & Suri, M. Relatively mild phenotype in a patient with interstitial 6q24.3-q25.2 deletion. *Clin Dysmorphol* **16**, 101-4 (2007).
365. Lukusa, T., Willekens, D., Lukusa, N., De Cock, F. & Fryns, J.P. Terminal 6q25.3 deletion and abnormal behaviour. *Genet Couns* **12**, 213-21 (2001).
366. Fryns, J.P., Vandenbergh, K. & Van den Berghe, H. Prune-belly anomaly and large interstitial deletion of the long arm of chromosome 6. *Ann Genet* **34**, 127 (1991).
367. Ito, H., Yamasaki, T., Okamoto, O. & Tahara, E. Infantile hemangioendothelioma of the liver in patient with interstitial deletion of chromosome 6q: report of an autopsy case. *Am J Med Genet* **34**, 325-9 (1989).
368. Schmid, W., D'Apuzzo, V. & Rossi, E. Trisomy 6q25 to 6qter in a severely retarded 7-year-old boy with turriccephaly, bow-shaped mouth, hypogenitalism and club feet. *Hum Genet* **46**, 279-84 (1979).
369. Lee, H.H. et al. Low frequency of the CYP21A2 deletion in ethnic Chinese (Taiwanese) patients with 21-hydroxylase deficiency. *Mol Genet Metab* **93**, 450-7 (2008).
370. Lee, H.H. Diversity of the CYP21P-like gene in CYP21 deficiency. *DNA Cell Biol* **24**, 1-9 (2005).
371. Lee, H.H. Chimeric CYP21P/CYP21 and TNXA/TNXB genes in the RCCX module. *Mol Genet Metab* **84**, 4-8 (2005).
372. Lee, H.H., Chang, S.F., Lo, F.S., Chao, H.T. & Lin, C.Y. Duplication of 111 bases in exon 1 of the CYP21 gene is combined with deletion of CYP21P-C4B genes in steroid 21-hydroxylase deficiency. *Mol Genet Metab* **79**, 214-20 (2003).
373. Rodriguez, L. et al. Terminal deletion of the chromosome 7(q36-qter) in an infant with sacral agenesis and anterior myelomeningocele. *Am J Med Genet* **110**, 73-7 (2002).
374. Rodriguez, L. et al. Pure partial trisomy 7q: two new patients and review. *Am J Med Genet* **113**, 218-24 (2002).
375. Ichioka, K., Yoshimura, K., Honda, T., Takahashi, A. & Terai, A. Paracentric inversion of chromosome 7(q22-31) associated with nonobstructive azoospermia. *Fertil Steril* **83**, 455-6 (2005).
376. Thai, H.T. et al. A new susceptibility locus for hypospadias on chromosome 7q32.2-q36.1. *Hum Genet* **124**, 155-60 (2008).
377. Asamoah, A., Nwankwo, M., Kumar, S.P., Ezhuthachan, S.G. & Van Dyke, D.L. Proximal chromosome 8q deletion in a boy with femoral bifurcation and other multiple congenital anomalies. *Am J Med Genet A* **127A**, 65-8 (2004).
378. Chen, C.P. et al. Second-trimester diagnosis of complete trisomy 9 associated with abnormal maternal serum screen results, open sacral spina bifida and congenital diaphragmatic hernia, and review of the literature. *Prenat Diagn* **24**, 455-62 (2004).
379. Seller, M.J., Bergbaum, A. & Daker, M.G. Trisomy 9 in an embryo with spina bifida. *Clin Dysmorphol* **7**, 217-9 (1998).

380. Sharony, R., Amiel, A., Einy, R. & Fejgin, M. Prenatal diagnosis of pericentric inversion in homologues of chromosome 9: a decision dilemma. *Am J Perinatol* **24**, 137-40 (2007).
381. Salihu, H.M., Boos, R., Tchuinguem, G. & Schmidt, W. Prenatal diagnosis of translocation and a single pericentric inversion 9: the value of fetal ultrasound. *J Obstet Gynaecol* **21**, 474-7 (2001).
382. Picardo Lopez, C., Ramos Corrales, C., Bello Gonzalez, J., Moran Cabre, A. & Sanchez Cascos, A. [Prune belly syndrome with associated anomalies and chromosome changes (20 p+)]. *An Esp Pediatr* **26**, 291-4 (1987).
383. Collodel, G. et al. TEM, FISH and molecular studies in infertile men with pericentric inversion of chromosome 9. *Andrologia* **38**, 122-7 (2006).
384. Vinci, G. et al. Association of deletion 9p, 46,XY gonadal dysgenesis and autistic spectrum disorder. *Mol Hum Reprod* **13**, 685-9 (2007).
385. Hampshire, D.J. et al. MORM syndrome (mental retardation, truncal obesity, retinal dystrophy and micropenis), a new autosomal recessive disorder, links to 9q34. *Eur J Hum Genet* **14**, 543-8 (2006).
386. Davidson, C.E., Li, Q., Churchill, G.A., Osborne, L.R. & McDermid, H.E. Modifier locus for exencephaly in Cecr2 mutant mice is syntenic to the 10q25.3 region associated with neural tube defects in humans. *Physiol Genomics* **31**, 244-51 (2007).
387. Michels, V.V., Driscoll, D.J., Ledbetter, D.H. & Riccardi, V.M. Phenotype associated with ring 10 chromosome: report of patient and review of literature. *Am J Med Genet* **9**, 231-7 (1981).
388. Leonard, N.J., Harley, F.L. & Lin, C.C. Terminal deletion of chromosome 10q at band 26.1: follow-up in an adolescent male with high-output renal failure from congenital obstructive uropathy. *Am J Med Genet* **86**, 115-7 (1999).
389. Le Caignec, C. et al. Complete sex reversal in a WAGR syndrome patient. *Am J Med Genet A* **143A**, 2692-5 (2007).
390. Helmuth, R.A., Weaver, D.D. & Wills, E.R. Holoprosencephaly, ear abnormalities, congenital heart defect, and microphallus in a patient with 11q-mosaicism. *Am J Med Genet* **32**, 178-81 (1989).
391. Bader, P.I., Haney, S.M., Munsick, R.A., Schubert, S.R. & Hodes, M.E. Brief clinical report: neural tube defects in dup(11q). *Am J Med Genet* **19**, 5-8 (1984).
392. Pihko, H., Therman, E. & Uchida, I.A. Partial 11q trisomy syndrome. *Hum Genet* **58**, 129-34 (1981).
393. Aurias, A. & Laurent, C. [Trisomy 11q. Individualization of a new syndrome]. *Ann Genet* **18**, 189-91 (1975).
394. Laurent, C., Biemont, M.C., Bethenod, M., Cret, L. & David, M. [2 cases of trisomy 11q(q23.2-- qter) with the same abnormality of external genitalia]. *Ann Genet* **18**, 179-84 (1975).
395. de Jong, J. et al. Further characterization of the first seminoma cell line TCam-2. *Genes Chromosomes Cancer* **47**, 185-96 (2008).
396. Sung, M.T. et al. Primary mediastinal seminoma: a comprehensive assessment integrated with histology, immunohistochemistry, and fluorescence in situ hybridization for chromosome 12p abnormalities in 23 cases. *Am J Surg Pathol* **32**, 146-55 (2008).

397. Martin, J.R., Wold, A. & Taylor, H.S. Ring chromosome 12 and severe oligospermia: a case report. *Fertil Steril* **90**, 443 e13-5 (2008).
398. Walczak-Sztulpa, J. et al. Chromosome deletions in 13q33-34: report of four patients and review of the literature. *Am J Med Genet A* **146**, 337-42 (2008).
399. Lin, H.Y. et al. Clinical characteristics and survival of trisomy 13 in a medical center in Taiwan, 1985-2004. *Pediatr Int* **49**, 380-6 (2007).
400. Rodriguez, J.I., Garcia, M., Morales, C., Morillo, A. & Delicado, A. Trisomy 13 syndrome and neural tube defects. *Am J Med Genet* **36**, 513-6 (1990).
401. Luo, J. et al. Neural tube defects and the 13q deletion syndrome: evidence for a critical region in 13q33-34. *Am J Med Genet* **91**, 227-30 (2000).
402. McKeown, C.M. & Donnai, D. Prune belly in trisomy 13. *Prenat Diagn* **6**, 379-81 (1986).
403. Beckmann, H., Rehder, H. & Rauskolb, R. Prune belly sequence associated with trisomy 13. *Am J Med Genet* **19**, 603-4 (1984).
404. Sutton, V.R., Coveler, K.J., Lalani, S.R., Kashork, C.D. & Shaffer, L.G. Subtelomeric FISH uncovers trisomy 14q32: lessons for imprinted regions, cryptic rearrangements and variant acrocentric short arms. *Am J Med Genet* **112**, 23-7 (2002).
405. Elliott, J., Maltby, E.L. & Reynolds, B. A case of deletion 14(q22.1-->q22.3) associated with anophthalmia and pituitary abnormalities. *J Med Genet* **30**, 251-2 (1993).
406. Fujimoto, A., Allanson, J., Crowe, C.A., Lipson, M.H. & Johnson, V.P. Natural history of mosaic trisomy 14 syndrome. *Am J Med Genet* **44**, 189-96 (1992).
407. Kaplan, L.C., Wayne, A., Crowell, S. & Latt, S.A. Trisomy 14 mosaicism in a liveborn male: clinical report and review of the literature. *Am J Med Genet* **23**, 925-30 (1986).
408. Vachvanichsanong, P., Jinorose, U. & Sangnuachua, P. Trisomy 14 mosaicism in a 5-year-old boy. *Am J Med Genet* **40**, 80-3 (1991).
409. Stahl, B.C., Patil, S.R., Syrop, C.H., Sparks, A.E. & Wald, M. Supernumerary minute ring chromosome 14 in a man with primary infertility and left varicocele. *Fertil Steril* **87**, 1213 e1-3 (2007).
410. Gustavsson, P. et al. Duplication 16q12.1-q22.1 characterized by array CGH in a girl with spina bifida. *Eur J Med Genet* **50**, 237-41 (2007).
411. Mabboux, P. et al. Pure and complete trisomy 18p due to a supernumerary marker chromosome associated with moderate mental retardation. *Am J Med Genet A* **143**, 727-33 (2007).
412. Tonni, G., Azzoni, D., Panteghini, M., Ventura, A. & Cavalli, P. First trimester diagnosis of iniencephaly associated with fetal malformations and trisomy 18: report of a new case and gene analysis on folate metabolism in parents. *Congenit Anom (Kyoto)* **47**, 101-4 (2007).
413. O'Reilly, G.C. & Shields, L.E. Karyotyping for isolated neural tube defects. A report of two cases. *J Reprod Med* **45**, 950-2 (2000).
414. Nivelon-Chevallier, A., Feldman, J.P., Justrabo, E. & Turc-Carel, C. [Trisomy 18 and prune belly syndrome]. *J Genet Hum* **33**, 469-74 (1985).
415. Frydman, M., Magenis, R.E., Mohandas, T.K. & Kaback, M.M. Chromosome Abnormalities in infants with prune belly anomaly: association with trisomy 18. *Am J Med Genet* **15**, 145-8 (1983).

416. Tsukahara, M., Imaizumi, K., Fujita, K., Tateishi, H. & Uchida, M. Familial Del(18p) syndrome. *Am J Med Genet* **99**, 67-9 (2001).
417. Nakano, S., Okuno, T., Hojo, H., Misawa, S. & Abe, T. 18p--syndrome associated with hemivertebrae, fused ribs and micropenis. *Jinrui Idengaku Zasshi* **22**, 27-32 (1977).
418. Zahed, L., Oreibi, G., Azar, C. & Salti, I. Ring chromosome 18q and jumping translocation 18p in an adult male with hypergonadotrophic hypogonadism. *Am J Med Genet A* **129A**, 25-8 (2004).
419. Chaabouni, M. et al. De novo trisomy 20p of paternal origin. *Am J Med Genet A* **143A**, 1100-3 (2007).
420. Amacker, E.A., Grass, F.S., Hickey, D.E. & Hisley, J.C. An association of prune belly anomaly with trisomy 21. *Am J Med Genet* **23**, 919-23 (1986).
421. Olinici, C.D., Butnariu, J., Popescu, A. & Giurguiman, M. Mosaic 45,xy,-21/46,xy in a child with G deletion syndrome I. *Ann Genet* **20**, 115-7 (1977).
422. Yosunkaya Fenerci, E. et al. Supernumerary chromosome der(22)t(11;22): Emanuel syndrome associates with novel features. *Genet Couns* **18**, 401-8 (2007).
423. Portnoi, M.F. et al. 22q11.2 duplication syndrome: two new familial cases with some overlapping features with DiGeorge/velocardiofacial syndromes. *Am J Med Genet A* **137**, 47-51 (2005).
424. Hou, J.W. Trisomy chromosome (22)(q13.1-qter) as a result of paternal inversion (22)(p11q13.1) proved using region-specific FISH probes. *Chang Gung Med J* **28**, 657-61 (2005).
425. Robin, N.H. et al. Polymicrogyria and deletion 22q11.2 syndrome: window to the etiology of a common cortical malformation. *Am J Med Genet A* **140**, 2416-25 (2006).
426. Seller, M.J., Mohammed, S., Russell, J. & Ogilvie, C. Microdeletion 22q11.2, Kousseff syndrome and spina bifida. *Clin Dysmorphol* **11**, 113-5 (2002).
427. Nickel, R.E. & Magenis, R.E. Neural tube defects and deletions of 22q11. *Am J Med Genet* **66**, 25-7 (1996).
428. Nickel, R.E. et al. Velo-cardio-facial syndrome and DiGeorge sequence with meningomyelocele and deletions of the 22q11 region. *Am J Med Genet* **52**, 445-9 (1994).
429. Forrester, S. et al. Kousseff syndrome caused by deletion of chromosome 22q11-13. *Am J Med Genet* **112**, 338-42 (2002).
430. Begleiter, M.L., Kulkarni, P. & Harris, D.J. Confirmation of trisomy 22 by trypsin-giemsa staining. *J Med Genet* **13**, 517-20 (1976).
431. Hol, F.A. et al. Identification and characterization of an Xq26-q27 duplication in a family with spina bifida and panhypopituitarism suggests the involvement of two distinct genes. *Genomics* **69**, 174-81 (2000).
432. Koc, A. et al. A boy with small supernumerary marker chromosome X identified by FISH. *Genet Couns* **18**, 393-9 (2007).
433. Visootsak, J. & Graham, J.M., Jr. Klinefelter syndrome and other sex chromosomal aneuploidies. *Orphanet J Rare Dis* **1**, 42 (2006).
434. Tartaglia, N. et al. A new look at XXYY syndrome: medical and psychological features. *Am J Med Genet A* **146A**, 1509-22 (2008).

435. Bleyl, S.B. et al. Brachyomesomelic dysplasia with Peters anomaly of the eye results from disruptions of the X chromosome near the SHOX and SOX3 genes. *Am J Med Genet A* **143A**, 2785-95 (2007).
436. Cheng, S.F., Rauen, K.A., Pinkel, D., Albertson, D.G. & Cotter, P.D. Xq chromosome duplication in males: clinical, cytogenetic and array CGH characterization of a new case and review. *Am J Med Genet A* **135**, 308-13 (2005).
437. Lutke Holzik, M.F. et al. Re-analysis of the Xq27-Xq28 region suggests a weak association of an X-linked gene with sporadic testicular germ cell tumour without cryptorchidism. *Eur J Cancer* **42**, 1869-74 (2006).
438. Schluth, C. et al. Prenatal sonographic diagnosis of the 49,XXXXY syndrome. *Prenat Diagn* **22**, 1177-80 (2002).
439. Verotti, A., Chiarelli, F., Violante, N., Pellegrini, E. & Palka, G. [49 XXXXY syndrome. Description of 2 clinical cases]. *Pediatr Med Chir* **8**, 575-8 (1986).
440. Hou, J.W. 49, XXXXY syndrome. *Chang Gung Med J* **27**, 551-4 (2004).
441. Manea, S.R. et al. Mosaicism for a small supernumerary ring X chromosome in a dysmorphic, growth-retarded male: mos47,XXY/48,XXY, +r(X). *Clin Genet* **52**, 432-5 (1997).
442. Alvarez-Nava, F. et al. FISH and PCR analysis of the presence of Y-chromosome sequences in a patient with Xq-isochromosome and testicular tissue. *Clin Genet* **55**, 356-61 (1999).
443. Guillen, D.R. et al. Prune-belly syndrome and other anomalies in a stillborn fetus with a ring X chromosome lacking XIST. *Am J Med Genet* **70**, 32-6 (1997).
444. Lin, H.J., Ndiforchu, F. & Patell, S. Exstrophy of the cloaca in a 47,XXX child: review of genitourinary malformations in triple-X patients. *Am J Med Genet* **45**, 761-3 (1993).
445. Pralea, C.E. & Mihalache, G. [Importance of Klinefelter syndrome in the pathogenesis of male infertility]. *Rev Med Chir Soc Med Nat Iasi* **111**, 373-8 (2007).
446. Rajender, S. et al. A novel human sex-determining gene linked to Xp11.21-11.23. *J Clin Endocrinol Metab* **91**, 4028-36 (2006).
447. Yoshinaga, A. et al. [A case of hypospadias with a dicentric Y chromosome]. *Nippon Hinyokika Gakkai Zasshi* **98**, 30-3 (2007).
448. Song, N.H. et al. Screening for Y chromosome microdeletions in idiopathic and nonidiopathic infertile men with varicocele and cryptorchidism. *Chin Med J (Engl)* **118**, 1462-7 (2005).
449. Rapley, E. Susceptibility alleles for testicular germ cell tumour: a review. *Int J Androl* **30**, 242-50; discussion 250 (2007).
450. Linger, R. et al. A physical analysis of the Y chromosome shows no additional deletions, other than Gr/Gr, associated with testicular germ cell tumour. *Br J Cancer* **96**, 357-61 (2007).
451. Boyadjiev, S.A. et al. Clinical and molecular characterization of the bladder exstrophy-epispadias complex: analysis of 232 families. *BJU Int* **94**, 1337-43 (2004).
452. Skare, J. et al. Interstitial deletion involving most of Yq. *Am J Med Genet* **36**, 394-7 (1990).

453. Rivera, H. et al. Malformed genitalia in the 47,XYY genotype. *Ann Genet* **22**, 225-7 (1979).
454. Buchanan, P.D., Wyandt, H.E., D'Ercole, A.J., Rao, K.W. & Hartsell, M.L. A mitotically unstable human dicentric Y chromosome in a male pseudohermaphrodite. *Cytogenet Cell Genet* **17**, 42-50 (1976).
455. Queipo, G. et al. Unusual mixed gonadal dysgenesis associated with Mullerian duct persistence, polygonadia, and a 45,X/46,X,idic(Y)(p) karyotype. *Am J Med Genet A* **136A**, 386-9 (2005).
456. Stuppia, L. et al. A quarter of men with idiopathic oligo-azoospermia display chromosomal abnormalities and microdeletions of different types in interval 6 of Yq11. *Hum Genet* **102**, 566-70 (1998).
457. Shirakawa, T. et al. Y chromosome (Yq11) microdeletions in idiopathic azoospermia. *Int J Urol* **4**, 198-201 (1997).
458. Reddy, K.S., Sulcova, V., Ho, C.K., Conner, E.D. & Khurana, A. An infant with a mosaic 45,X/46,X,psu dic(Y) (pter-->q11.2::q11.2-->pter) karyotype and mixed gonadal dysgenesis studied for extent of mosaicism in the gonads. *Am J Med Genet* **66**, 441-4 (1996).
459. Lin, Y.H. et al. Isochromosome of Yp in a man with Sertoli-cell-only syndrome. *Fertil Steril* **83**, 764-6 (2005).
460. Castro, A. et al. YqTER deletion causes arrest of spermatogenesis in early puberty. *J Pediatr Endocrinol Metab* **17**, 1675-8 (2004).
461. Codina-Pascual, M. et al. FISH characterization of a dicentric Yq (p11.32) isochromosome in an azoospermic male. *Am J Med Genet A* **127A**, 302-6 (2004).
462. Abdelmoula, N.B. & Amouri, A. [Dicentric Y chromosome]. *Ann Biol Clin (Paris)* **63**, 363-75 (2005).
463. Spinner, N.B. et al. Intracytoplasmic sperm injection (ICSI) with transmission of a ring(Y) chromosome and ovotesticular disorder of sex development in offspring. *Am J Med Genet A* **146A**, 1828-31 (2008).
464. Bertini, V., Canale, D., Bicocchi, M.P., Simi, P. & Valetto, A. Mosaic ring Y chromosome in two normal healthy men with azoospermia. *Fertil Steril* **84**, 1744 (2005).
465. Roovere, T. et al. Cytogenetic and molecular characterization of the derivative Y chromosome: a case study of an azoospermic patient. *Clin Genet* **72**, 460-3 (2007).
466. Marchina, E. et al. Chromosome abnormalities and Yq microdeletions in infertile italian couples referred for assisted reproductive technique. *Sex Dev* **1**, 347-52 (2007).
467. Couturier-Turpin, M.H., Ingster, O., Salat-Baroux, J. & Feldmann, G. Report of a family case of satellite Y chromosome associated with a severe oligoasthenoteratospermia. A review of the literature. *Ann Genet* **37**, 200-6 (1994).
468. Layman, L.C., Tho, S.P., Clark, A.D., Kulharya, A. & McDonough, P.G. Phenotypic spectrum of 45,X/46,XY males with a ring Y chromosome and bilaterally descended testes. *Fertil Steril* (2008).
469. Chen, H., Gershnik, J.J., Mailhes, J.B. & Sanusi, I.D. Omphalocele and partial trisomy 1q syndrome. *Hum Genet* **53**, 1-4 (1979).

470. Vialard, F. et al. Whole-arm translocations between chromosome 1 and acrocentric G chromosomes are associated with a poor prognosis for spermatogenesis: two new cases and review of the literature. *Fertil Steril* **86**, 1001 e1-5 (2006).
471. Leonard, N.J. & Tomkins, D.J. Diploid/tetraploid/t(1;6) mosaicism in a 17-year-old female with hypomelanosis of Ito, multiple congenital anomalies, and body asymmetry. *Am J Med Genet* **112**, 86-90 (2002).
472. Quintana de la Rosa, J.L., Gallegos Avila, G., Garcia Cavazos, R. & Zungri Telo, E. Chromosomal translocation 3;22 in an infertile man. *Fertil Steril* **75**, 1222-3 (2001).
473. Salahshourifar, I. et al. De novo complex chromosomal rearrangement of 46, XY, t (3; 16; 8) (p26; q13; q21.2) in a non-obstructive azoospermic male. *J Appl Genet* **48**, 93-4 (2007).
474. Peng, H.H., Wang, T.H., Hsueh, D.W., Chang, S.D. & Soong, Y.K. Prenatal diagnosis of partial trisomy 12q: clinical presentations and outcome. *Prenat Diagn* **25**, 470-4 (2005).
475. Saad, A., Khelif, M., Kharraf, H. & Bouzakoura, C. [4p trisomy secondary to paternal translocation t(4p-;15q+)]. *Ann Pediatr (Paris)* **38**, 350-4 (1991).
476. Matthaei, A. et al. Small reciprocal insertion detected by spectral karyotyping (SKY) and delimited by array-CGH analysis. *Eur J Med Genet* **48**, 328-38 (2005).
477. Neu, R.L., Shott, R.J. & Gardner, L.I. 4p- phenotype in an infant with t(4p-;19p or q+)mat translocation. *Am J Dis Child* **129**, 363-5 (1975).
478. Jinno, Y., Matsuda, I. & Kajii, T. Trisomy 17p due to A t(5;17) (p15;p11) pat translocation. *Ann Genet* **25**, 123-5 (1982).
479. Pernice, F., Mazza, G., Puglisi, D., Luppino, M.G. & Frisina, N. Nonrobertsonian translocation t(6;11) is associated with infertility in an oligoazoospermic male. *Fertil Steril* **78**, 192-4 (2002).
480. Rampersaud, E. et al. Whole genomewide linkage screen for neural tube defects reveals regions of interest on chromosomes 7 and 10. *J Med Genet* **42**, 940-6 (2005).
481. Lukusa, T., Vermeesch, J.R. & Fryns, J.P. De novo deletion 7q36 resulting from a distal 7q/8q translocation: phenotypic expression and comparison to the literature. *Genet Couns* **16**, 1-15 (2005).
482. Aydos, S.E. & Tukun, A. Infertility in a man with oligoasthenoteratozoospermia associated with nonrobertsonian translocation t(9;15)(p10;q10). *Fertil Steril* **86**, 1001 e7-9 (2006).
483. Morel, F. et al. Lack of intraindividual variation of unbalanced spermatozoa frequencies from a 46,XY,t(9;22)(q21;q11.2) carrier: case report. *Hum Reprod* **19**, 2227-30 (2004).
484. Roos, A. et al. Submicroscopic unbalanced translocation resulting in del10p/dup13q detected by subtelomere FISH. *Eur J Med Genet* **49**, 505-10 (2006).
485. Engiz, O. et al. 31 cases with oculoauriculovertebral dysplasia (Goldenhar syndrome): clinical, neuroradiologic, audiologic and cytogenetic findings. *Genet Couns* **18**, 277-88 (2007).

486. Chen, C.P. et al. Prenatal diagnosis of a micropenis in a male fetus with partial trisomy 12q (12q24.32-->qter) and partial monosomy 21q (21q22.2-->ter-->qter). *Prenat Diagn* **26**, 757-9 (2006).
487. Ozalp, O. et al. 45,XY,der(13;14)(q10;q10) in an azoospermic man with hypogonadotrophic hypogonadism. *Asian J Androl* **8**, 751-3 (2006).
488. Finch, K.A. et al. Nuclear organization in human sperm: preliminary evidence for altered sex chromosome centromere position in infertile males. *Hum Reprod* **23**, 1263-70 (2008).
489. Lee, S. et al. Molecular and cytogenetic characterization of two azoospermic patients with X-autosome translocation. *J Assist Reprod Genet* **20**, 385-9 (2003).
490. Hwang, S.H. et al. [A case of male infertility with a reciprocal translocation t(X;14)(p11.4;p12)]. *Korean J Lab Med* **27**, 139-42 (2007).
491. Fryns, J.P., Devriendt, K. & Moerman, P. Lumbosacral spina bifida and myeloschisis in a female foetus with de novo X/autosomal translocation (t(X;22)(q27;q12)). *Genet Couns* **7**, 159-60 (1996).
492. Sato, M., Kuwana, N., Kojima, Y., Tanaka, N. & Kitamura, H. [Chronic subdural hematoma with a markedly fibrous hypertrophic membrane. Case report]. *Neurol Med Chir (Tokyo)* **30**, 838-41 (1990).
493. Pabst, B. et al. Reciprocal translocation between Y chromosome long arm euchromatin and the short arm of chromosome 1. *Ann Genet* **45**, 5-8 (2002).
494. Thauvin-Robinet, C. et al. Cloacal exstrophy in an infant with 9q34.1-qter deletion resulting from a de novo unbalanced translocation between chromosome 9q and Yq. *Am J Med Genet A* **126A**, 303-7 (2004).
495. Alves, C., Carvalho, F., Cremades, N., Sousa, M. & Barros, A. Unique (Y;13) translocation in a male with oligozoospermia: cytogenetic and molecular studies. *Eur J Hum Genet* **10**, 467-74 (2002).
496. Yoshida, A., Nakahori, Y., Kuroki, Y., Miura, K. & Shirai, M. An azoospermic male with an unbalanced autosomal-Y translocation. *Jpn J Hum Genet* **42**, 451-5 (1997).
497. Brisset, S. et al. Cytogenetic, molecular and testicular tissue studies in an infertile 45,X male carrying an unbalanced (Y;22) translocation: case report. *Hum Reprod* **20**, 2168-72 (2005).